INTERRELATED CONTRIBUTIONS TO FRESHWATER SCIENCE OVER 78 YEARS: A GUIDE TO PUBLISHED WORK FROM THE FRESHWATER BIOLOGICAL ASSOCIATION, INSTITUTE OF FRESHWATER ECOLOGY AND CENTRE FOR ECOLOGY AND HYDROLOGY, 1929–2006

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Introduction[*]

Here we introduce a new listing of published scientific contributions from the Freshwater Biological Association (FBA) and its later Research Council associates – the Institute of Freshwater Ecology (1989–2000) and the Centre for Ecology and Hydrology (2000+). The period 1929–2006 is covered. We offer below information on specific features of the listing; also an outline of influences that underlay the research, and its scientific scope.

Our main aim has been to offer a convenient reference work to the large body of information now available. Remarkably, but understandably, the titles are widely regarded as the domain of specialists; probably few are consulted by administrators or general naturalists. Perceived obstacles relate to (i) knowledge of existing contributions, (ii) access to them, (iii) understanding in a specialism. Here our concern is mainly with (i) and briefly with (ii) and (iii).

The compilation extends an earlier list assembled by one of us in 1979. Large changes have occurred since that date. Regular consolidated listings within Annual Reports of the FBA were discontinued, as were individual reprints and bound annual collections of reprints available from the FBA library. Most important of all, in 1989 much freshwater research and most active researchers from the FBA, together with some staff transferred from the Institute of Terrestrial Ecology, were reorganised within another body administered by the Natural Environment Research Council, as the Institute of Freshwater Ecology (IFE). The Institute of Freshwater Ecology later provided part of the Centre for Ecology and Hydrology (CEH). The directly

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associated IFE and CEH publications on *fresh waters* are here combined with those of the FBA, there being much overlap in authors and subject matter. Since 1990 the work by IFE and its derived CEH staff, plus work by FBA research students and fellows, account for most of the on-going field and laboratory research. The three affiliations are distinguished separately in the present listing.

The listing (of over 4400 titles) is chronological by year of publication, and within-years alphabetical by authors. Publications are identified by numbers in superscripts. The listing can be searched for publications by any specific author, or on organisms named in a title, by electronic means.

The listing is not without some technical omissions and inconsistencies. Accents are omitted, as are abstracts, edited books and journal-parts, newspaper articles, and many contract reports. Latin names are not italicised. There is inclusion of some aspects of related topics such as soil science, and works assisted by visits to the main institutions.

Most publications have appeared in scientific journals, books and edited proceedings of meetings. Some are directly published by, and available from, the Freshwater Biological Association. Its library contains these and many other, and can be consulted by members of the Association. Availability from other libraries varies – the British Library is the most comprehensive, with a postal service. Electronic availability applies to most mainstream journals from the 1980s onwards.

We are greatly indebted to Olive Jolly of the FBA library staff for the final assembly of the listing.

In this introductory guide, we provide a short sample of works (as *examples* only!) from the listing. The full listing will be available on the internet (www.fba.org.uk/index/journals/fwforum) from September 2007. A printed version is obtainable, price £7.50 (plus packing & postage of £1.60 UK / £2.70 overseas), from the following address:

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Scope and influences

Although virtually all contributions relate to freshwater science, there is a wide range of subject matter. The broad topics included are physical, chemical and biological, the last with components of plant, animal and microbiological science. Their interactions are, of course, the essence of ecology and environmental science. Here the dynamics of change cannot be understood without information on the structure and components of the system involved. In biology, the subsequent species-resolution and identification account for numerous taxonomic contributions. Complementary to structure, the functional performance of organisms

underlies relationships with the environment. This draws upon studies of physiology, here particularly found in work on bacteria, algae, protozoa, Crustacea, macrophytes and fish; also of functional morphology and behaviour.

The establishment of change itself involves time-series of varying extent that are abundantly represented. They exceed spans of 30 years in some population and community studies of phytoplankton, zooplankton and fish, and of associated physical plus chemical change in the water environment. Very short-term changes – e.g. hour-by-hour – have fewer studies, but these include attempts to resolve and interpret day-night cycles in the plankton, stream invertebrates and changing lake stratification. At another extreme of time-scale, changing characteristics of lakes over late-glacial and post-glacial time have been deduced from the layered sediments and their biological and chemical inclusions.

The variety of topics represented, and their development over time, have been shaped by at least five main influences.

Individual interests and skills have always been important. Each member of staff brought new potential, as did visiting workers and students. The policy of the early FBA was to recruit promising individuals and give them the freedom to develop their chosen research.

Planned response to topical economic and environmental issues was present from the early days, but grew in importance as the 20th century progressed. In part this reflected the changing balance between 'curiosity-driven' and 'funding-driven' research, although both influences were always present. The latter led, after 1980, to a number of large multi-national projects.

Availability of accessible and promising environments was another, geographical, factor. The originally chosen region was that of the Cumbrian lakes with associated streams. Later, additional centres of research were based on calcareous running waters of the south of England, the newly impounded River Tees in Pennine uplands, the Shropshire-Cheshire meres, Scottish lochs, and rivers of eastern England. Other regions – some abroad – figure in shorter expeditions and cooperative ventures.

Available methods and facilities naturally determined the types of research that were practicable. There was a general progression with time linked to technological progress and theoretical insight. Special locally devised facilities were repeatedly influential. Examples were the experimental enclosures or mesocosms pioneered by the FBA for a lake ('Lund tubes') and artificial streams (e.g. the Waterstone channel).

Transmission of inspiration and expertise between individuals has been a potent influence in the chain of scientific developments. Additionally, there are many examples of cooperative projects.

Contributions to general issues of freshwater science

The period covered has seen a strong development of freshwater science. Some main sectors of active advance are distinguished below, with example-contributions from the present literature.

(1) *Lake hydrodynamics* has combined observational, theoretical and modelling approaches to the nature and control of water movements. There have been major contributions centred on Windermere, with prominence to seasonal stratification[591], internal waves[257], wind-induced currents in near-surface water[1755], horizontal distributions[321], and linked consequences for plankton[453] in this and neighbouring lakes[3977].

(2) *Basic chemical kinetics and reactivity* have been interpreted from experimental work in the laboratory supplemented by that on larger enclosures. Examples include work on redox-controlled reactions[1956] and complex-formation[2247] in anoxic lake environments such as hypolimnia; reactivity of humic material[4082]; and the chemical exchanges that involve solid-liquid interfaces as on lake sediments[102] and in-stream flows[3295]. Extension to chemical circulations in natural systems has been aided by information from radionucleides[3938] and isotope ratios (e.g. $^{13}C/^{12}C$).

(3) *Major ionic components* determine the gross salinity range of inland waters. Their quantitative variation in time can be marked and systematic in lakes and rivers on seasonal and long-term scales[1917]. Susceptibility to mineral weathering leads to an overall altitudinal correlation in Cumbrian waters[378]. Concentrations of calcium and bicarbonate have much biological significance, including biodeposition[4080]. When low, the effects of atmospheric acid deposition have been traced[2016], with a partial reversal in Cumbria after 1980 following a reduction in acid emissions[4083].

(4) *Bacterial activities and distributions* are responsible for many chemical fluxes and changes in natural waters. They have been studied in vertically stratified lake systems of Cumbria, as in relation to planktonic abundance[1021], oxidation-reduction gradients[1987], and sediment–water interfaces[1579], with seasonal denitrification[1654] as one important consequence. Work in Dorset has drawn attention to the oft-neglected epiphytic bacteria of vegetated streams[2259].

(5) *Nutrient limitation of primary biological production* has been indicated by observed correlations on population abundance in time, including the seasonal dynamics of phytoplankton[223] and associations with long-term enrichment (eutrophication)[3887]. More resolved evidence was obtainable experimentally, as from cultures (bioassays) with graded quantitative and qualitative additions of nutrients to cultures[1240] or mesocosms[2354]; also by deductions from changing chemical composition of biomass[2246] and overall nutrient budgets and loadings[2952]. Pathways of nutrient availability in nature are also significant, as by sediment-water exchange[3761], atmosphere-water exchange[3828], and the biological fixation of molecular nitrogen[907].

(6) *Aquatic photosynthesis* has provided a means to assess the utilization of solar energy[1918] and inorganic carbon[3420], to recognise situations where these inputs are rate-limiting[3791], and to assess comparative magnitudes of primary production by aquatic communities[603]. All natural waters have vertical light gradients[985], over which depth-profiles of photosynthesis[386] (and sometimes derived growth[487]) have been measured in field experiments on suspended samples, either of native or cultured material. From these, or from exposures in the laboratory[725], physiological variables have been derived that can, in conjunction with environmental variables, allow photosynthetic production per unit area to be estimated[388]. Work has included phytoplankton and attached algae; in aquatic macrophytes there are often additional limitations for CO_2 transport[4136].

(7) *Solute – including nutrient – dynamics in running water* involve time-relationships that are complicated by water travel and replacement as well as various sources of input and uptake. Insights have been gained from time-courses at individual sites[2711], the longitudinal succession of concentrations and fluxes[3654], experimental introductions that involve comparison with a ‘conservative’ tracer[4079], and catchment budgets[4010]. Strong chemical influences may develop from the growth and metabolism of the attached organisms (as periphyton, epilithon, biofilms) of shallow streams[1722] and of the weed-beds of rivers[3942]. Chemical and faunistic relationships have been demonstrated along the longitudinal course of a Cumbrian river[1496].

(8) *Population abundance and cycles* have been followed, often over many decades, for some planktonic algae[1113], ciliates[1744], rotifers[3078] and crustaceans[1604], attached algae[1901], benthic invertebrates[381], and fishes of streams[1671] and lakes[1403]. The measures of abundance have been varied, as has the feasibility of resolving quantitative parameters

of population dynamics, calculating production rates, distinguishing cohorts or year-classes, and identifying the controlling factors of the environment. Numbers of some natural populations – as of perch and pike in Windermere[2440] – have been experimentally manipulated. Important vertical transfers of organisms have been demonstrated with the buoyancy[1254], sedimentation[1796] or active migration[1645] of plankton, recruitment from benthic stages of a life history[280], and generation of invertebrate dispersal in streams, including downstream drifting[4017].

(9) *Food-web interactions* are important in the control of energy flow, structure and succession within natural communities. They may operate via grazing, predation, parasitism and detritivory. The first three have been known to generate steep declines of the consumed populations. In the lake plankton there is evidence of intense grazing of algae during the early summer maximum of *Daphnia* spp.[4163], and of selective mortalities due to epidemics of parasitism by periodically abundant micro-fungi[2046]. Some protozoans are also significant grazers[2708]. Grazers and predators coexist in the macro-invertebrate faunas of streams, with consequences traced for change or stability of communities[4111] and the diverse ecological strategies of individual organisms or functional group of organisms (guild). Predation by fish can be a major eliminating influence on communities of benthic invertebrates[713], and even – by piscivores like the pike – upon the fish communities themselves[2440].

(10) *The physiological basis* for ecological occurrence, function and survival has been sought in experimental studies. Examples include nutritional requirements of bacteria[2328], seasonality in the growth of fishes[526], stress reactions of trout[2876], food digestion in *Gammarus*[2272], respiration under anoxia in some ciliate protozoa[2188], taxes in phytoflagellates[4107], photosynthetic characteristics of phytoplankton[725] and macrophytes[2216], response to temperature in various algae[4264] and fish[3141], and quantifying the components of the energy budget of fish[3746]. Enhanced physiological versatility has been shown to result from some symbiotic associations that involve protozoa[3046].

(11) *The ecology of large rivers* has introduced issues unfamiliar or unrepresented in small streams. A true plankton often develops locally. Examples have been studied in the rivers Thames[1309], Severn[3097], Great Ouse[3539] and Humber system[3553] of Britain, and on a much larger scale in the Nile[1345].

(12) *Biodiversity, taxonomy and the fine genetic structure of populations* are all expressions of evolutionary biology. Studies of classical taxonomy and aids to identification are numerous and have underpinned most ecological work. Those of fine genetic structure have been made possible by advances in molecular biology; examples appear for bacteria[2781] and planktonic Crustacea[3880]. These advances have been applied to the identification[2877] and retrieval[2872] of bacterial components. Microbial biodiversity has implications for prior dispersibility[3747] and the chemical functioning of water-bodies[3498]. Another aspect of biodiversity is adaptive radiation, conspicuously demonstrated by work on the functional morphology of Crustacea[1155].

(13) *Indicator organisms and assemblages* have long been sought to provide an integrated measure of diverse, biologically discriminatory, environmental conditions. One system (RIVPACS), intended to assess the water quality of streams, is based on the occurrence and non-occurrence of stream macroinvertebrates[3124], with comparison between the actual occurrence of animals and that predicted for a similar stream with 'excellent' water quality[4106].

(14) *Reconstruction of past environments and biota of inland waters* has made much progress, in Britain mainly based on the biological and chemical record over the late-glacial and post-glacial periods in layered and dated lake sediments. Most information has come from persistent microfossils, notably diatoms[855] and pollen[632], complemented by major and minor chemical components[1065], radioisotopes[1109], and remanent magnetisation[975]. The Windermere Interstadial (late glacial) has been characterised. There have been detailed studies on many Cumbrian lakes[1790] and tarns[632], with some additional work on more northerly lakes[1043].

(15) *Reservoir creation* with water impoundment has led to changes in many river systems. Recognition and analysis of such changes – affecting water temperature[2406], sediments[2393], plankton[2486], benthic invertebrates[1353] and fish populations[2175] – were pursued in a long-term study of the upper River Tees[1445].

(16) *Human constraints upon change* (conservation) in populations, communities and ecosystems have been applied in the management of rivers[2752] and lakes[3203], and in the protection of endangered species – especially fishes[3008]. Examples include the last two populations of vendace[3008] in Britain.

(17) *Tropical freshwater science* has added wider perspectives. It has had major contributions from the FBA. These were drawn from the lakes and rivers of Africa[2299] plus Lake Titicaca[619] in South America, and often involved individuals with prior tropical experience. There resulted studies of fishes[1012], invertebrates[500] and phytoplankton[2361]; of seasonal cycles in Lake Victoria[726]; the comparative chemical composition of African inland waters[681]; and general issues of evolution[850], conservation[2075] and aquatic dynamics[3710] under tropical conditions.

(18) *Mathematical modelling* is now widely used in science to fit quantitative relationships into a combined system whereby outputs can be gauged from given inputs. This has had a long history in the production ecology of plankton[388]. Loss processes[1911], population regulation[4394] and community regulation[3919] of phytoplankton have also been modelled, as has population regulation in the brown trout[3158] and its growth in relation to food intake[3626] and temperature[1857]. Models of the growth of fish, especially salmonids, have been used cooperatively throughout Europe to assess the growth potential of fish stocks[4300]. In chemical studies there have been examples from inorganic–organic (e.g. humic) linkages[3002] and consequences of acidification in catchments[2787].

(19) *Climatic changes* of marine or atmospheric origin have been clearly detected in long-term records since about 1950. The marine influence was associated with the northerly or southerly disposition of the North Atlantic Drift[3286] ('Gulf Stream'), meteorologically quantified by the North Atlantic Oscillation. This has been found to generate corresponding year-to-year oscillations in the surface temperature and vertical stratification of Cumbrian lakes, and conditions in Cumbrian trout streams, that have consequences for plankton[3644] and fish[3839] deduced with varying certainty. Separately there has been a small long-term rise of lake surface temperature[4291], mainly induced by the rising concentration of atmospheric carbon dioxide.

(20) *Subject surveys and syntheses* have offered opportunity to interrelate individual contributions and specialisms within broader perspectives of freshwater science. They have potential at introductory[243] and advanced[3710] levels, with approaches that are predominantly structural or dynamic. There may be a regional basis, as in several accounts of the English Lakes[918]. Others have been organised around individual species[748], groups[3250] and communities[4394]. Many subjects under active study have been served by introductory reviews[1533] in Annual Reports of the Freshwater Biological Association.

References cited above as examples of the published work

Attributions to FBA, IFE and CEH are given at the end of each reference, as follows: FBA (all works published in 1989 and before; also later works by FBA authors), IFE (works published 1990–1999), CEH (2000+), or joint FBA and CEH/IFE.

The full list of published work is available on the internet or as a print copy (see above for details).

1940–1950s

102. Mortimer, C.H. (1941). The exchange of dissolved substances between mud and water in lakes. I and II. *Journal of Ecology* **29**, 280-329. FBA

223. Lund, J.W.G. (1950). Studies on Asterionella formosa Hass. II. Nutrient depletion and the spring maximum. Part I. Observations on Windermere, Esthwaite Water and Blelham Tarn. *Journal of Ecology* **38**, 1-14. FBA

243. Macan, T.T. & Worthington, E.B. (1951). *Life in lakes and rivers*. Collins: The New Naturalist, London, 272p. FBA

257. Mortimer, C.H. (1952). Water movements in lakes during summer stratification; evidence from the distribution of temperature in Windermere. *Philosophical Transactions of the Royal Society (B)* **236**, 355-404. FBA

280. Lund, J.W.G. (1954). The seasonal cycle of the plankton diatom, Melosira italica (Ehr.) Kutz. subsp. subarctica O. Mull. *Journal of Ecology* **42**, 151-179. FBA

321. Mortimer, C.H. (1955). The dynamics of the Autumn overturn in a lake. *General Assembly of the International Union of Geodesy and Geophysics, Rome* **3**, 15-24. FBA

378. Mackereth, F.J.H. (1957). Chemical analysis in ecology illustrated from Lake District tarns and lakes. 1. Chemical analysis. *Proceedings of the Linnaean Society of London* **167**, 159-164. FBA

381. Mundie, J.H. (1957). The ecology of Chironomidae in storage reservoirs. *Transactions of the Royal Entomological Society of London* **109**, 149-232. FBA

386. Talling, J.F. (1957). Photosynthetic characteristics of some freshwater plankton diatoms in relation to underwater radiation. *New Phytologist* **56**, 29-50. FBA
388. Talling, J.F. (1957). The phytoplankton population as a compound photosynthetic system. *New Phytologist* **56**, 133-149. FBA

1960s

453. Colebrook, J.M. (1960). Plankton and water movements in Windermere. *Journal of Animal Ecology* **29**, 217-240. FBA
487. Cannon, D., Lund, J.W.G., & Sieminska, J. (1961). The growth of Tabellaria flocculosa (Roth) Kutz. var. flocculosa (Roth) Knuds. under natural conditions of light and temperature. *Journal of Ecology* **49**, 277-287. FBA
500. Fryer, G. (1961). The developmental history of Mutela bourguignati (Ancey) Bourguignat (Mollusca: Bivalvia). *Philosophical Transactions of the Royal Society (B)* **244**, 259-298. FBA
526. Swift, D.R. (1961). The annual growth-rate cycle in brown trout (Salmo trutta Linn.) and its cause. *Journal of Experimental Biology* **38**, 595-604. FBA
591. Lund, J.W.G., Mackereth, F.J.H., & Mortimer, C.H. (1963). Changes in depth and time of certain chemical and physical conditions and of the standing crop of Asterionella formosa Hass. in the North Basin of Windermere in 1947. *Philosophical Transactions of the Royal Society (B)* **246**, 255-290. FBA
603. Westlake, D.F. (1963). Comparisons of plant productivity. *Biological Reviews* **38**, 385-425. FBA
619. Gilson, H.C. (1964). Lake Titicaca. *Verhandlungen der Internationalen Vereinigung fur Theoretische und Angewandte Limnologie* **15** 112-127. FBA
632. Pennington, W. (1964). Pollen analyses from the deposits of six upland tarns in the Lake District. *Philosophical Transactions of the Royal Society (B)* **248**, 205-244. FBA
681. Talling, J.F. & Talling, I.B. (1965). The chemical composition of African lake waters. *Internationale Revue der Gesamten Hydrobiologie und Hydrographie* **50**, 421-463. FBA
713. Macan, T.T. (1966). The influence of predation on the fauna of a moorland fishpond. *Archiv fur Hydrobiologie* **61**, 432-452. FBA
725. Talling, J.F. (1966). Photosynthetic behaviour in stratified and unstratified lake populations of a planktonic diatom. *Journal of Ecology* **54**, 99-127. FBA

726. Talling, J.F. (1966). The annual cycle of stratification and phytoplankton growth in Lake Victoria (East Africa). *Internationale Revue der Gesamten Hydrobiologie und Hydrographie* **51**, 545-621. FBA
748. Frost, W.E. & Brown, M.E. (1967). *The trout*. Collins: The New Naturalist, London, 286p + 17 plates. FBA
850. Fryer, G. (1969). Speciation and adaptive radiation in African lakes. *Verhandlungen der Internationalen Vereinigung fur Theoretische und Angewandte Limnologie* **17**, 303-322. FBA
855. Haworth, E.Y. (1969). The diatoms of a sediment core from Blea Tarn, Langdale. *Journal of Ecology* **57**, 429-439. FBA
907. Horne, A.J. & Fogg, G.E. (1970). Nitrogen fixation in some English lakes. *Proceedings of the Royal Society (B)* **175**, 351-366. FBA

1970s

918. Macan, T.T. (1970). *Biological studies of the English lakes*. Longman, London, 260p. FBA
975. Mackereth, F.J.H. (1971). On the variation in direction of the horizontal component of remanent magnetisation in lake sediments. *Earth and Planetary Science Letters* **12**, 332-338. FBA
985. Talling, J.F. (1971). The underwater light climate as a controlling factor in the production ecology of freshwater phytoplankton. *Mitteilungen der Internationalen Vereinigung fur Theoretische und Angewandte Limnologie* **No. 19**, 214-243. FBA
1012. Fryer, G. & Iles, T.D. (1972). *The cichlid fishes of the great lakes of Africa: their biology and evolution*. Oliver & Boyd, Edinburgh, 641p. FBA
1021. Jones, J.G. (1972). Studies of freshwater bacteria: association with algae and alkaline phosphatase activity. *Journal of Ecology*, **60**, 59-75. FBA
1043. Pennington, W., Haworth, E.Y., Bonny, A.P., & Lishman, J.P. (1972). Lake sediments in northern Scotland. *Philosophical Transactions of the Royal Society (B)* **264**, 191-294. FBA
1065. Cranwell, P.A. (1973). Chain-length distribution of n-alkanes from lake sediments in relation to post-glacial environmental change. *Freshwater Biology* **3**, 259-265. FBA
1109. Pennington, W., Cambray, R.S., & Fisher, E.M. (1973). Observations on lake sediments using fallout 137Cs as a tracer. *Nature* **242**, 324-

326. FBA

1113. Reynolds, C.S. (1973). The seasonal periodicity of planktonic diatoms in a shallow eutrophic lake. *Freshwater Biology* **3**, 89-110. FBA

1155. Fryer, G. (1974). Evolution and adaptive radiation in the Macrothricidae (Crustacea: Cladocera), a study in comparative functional morphology. *Philosophical Transactions of the Royal Society (B)* **269**, 137-274. FBA

1240. Lund, J.W.G., Jaworski, G.H.M., & Butterwick, C. (1975). Algal bioassay of water from Blelham Tarn, English Lake District and the growth of planktonic diatoms. *Archiv fur Hydrobiologie Supplementband* **49**, 49-69. FBA

1254. Reynolds, C.S. (1975). Interrelations of photosynthetic behaviour and buoyancy regulation in a natural population of a blue-green alga. *Freshwater Biology* **5**, 323-338. FBA

1309. Lack, T.J. & Berrie, A.D. (1976). Phytoplankton production in the rivers Thames and Kennet at Reading during 1970. *Symposium of the British Ecological Society* **16**, 43-62. FBA

1345. Talling, J.F. (1976). Phytoplankton: composition, development and productivity. In *The Nile, biology of an ancient river* (ed J. Rzoska), pp. 385-402. Junk, The Hague. FBA

1353. Armitage, P.D. (1977). Development of the macro-invertebrate fauna of Cow Green reservoir (Upper Teesdale) in the first five years of its existence. *Freshwater Biology* **7**, 441-454. FBA

1403. Le Cren, E.D., Kipling, C., & McCormack, J.C. (1977). A study of the numbers, biomass and year-class strengths of perch (Perca fluviatilis L.) in Windermere from 1941 to 1966. *Journal of Animal Ecology* **46**, 281-307. FBA

1445. Crisp, D.T. (1978). The freshwaters of the Cow Green area before and after impoundment, with special reference to the fauna. In *Upper Teesdale. The area and its natural history* (ed A.R. Clapham), pp. 179-190. Collins, London. FBA

1496. Minshall, G.W. & Minshall, J.N. (1978). Further evidence on the role of chemical factors in determining the distribution of benthic invertebrates in the River Duddon. *Archiv fur Hydrobiologie* **83**, 324-355. FBA

1533. Canter, H.M. (1979). Fungal and protozoan parasites and their importance in the ecology of the phytoplankton. *Report of the Freshwater Biological Association* **47**, 43-50. FBA

1579. Jones, J.G., Orlandi, M.J.L.G., & Simon, B.M. (1979). A

microbiological study of sediments from the Cumbrian lakes. *Journal of General Microbiology* **115**, 37-48. FBA

1604. Smyly, W.J.P. (1979). Population dynamics of Daphnia hyalina Leydig (Crustacea: Cladocera) in a productive and an unproductive lake in the English Lake District. *Hydrobiologia* **64**, 269-278. FBA

1980s

1645. Heaney, S.I. & Furnass, T.I. (1980). Laboratory models of diel vertical migration in the dinoflagellate Ceratium hirundinella. *Freshwater Biology* **10**, 163-170. FBA

1654. Jones, J.G., Downes, M.T., & Talling, I.B. (1980). The effect of sewage effluent on denitrification in Grasmere (English Lake District). *Freshwater Biology* **10**, 341-359. FBA

1671. Mann, R.H.K. (1980). The numbers and production of pike (Esox lucius) in two Dorset rivers. *Journal of Animal Ecology* **49**, 899-915. FBA

1722. Casey, H., Clarke, R.T., & Marker, A.F.H. (1981). The seasonal variation in silicon concentration in chalk-streams in relation to diatom growth. *Freshwater Biology* **11**, 335-344. FBA

1744. Finlay, B.J. (1981). Oxygen availability and seasonal migrations of ciliated protozoa in a freshwater lake. *Journal of General Microbiology* **123**, 173-178. FBA

1755. George, D.G. (1981). Wind-induced water movements in the South Basin of Windermere. *Freshwater Biology* **11**, 37-60. FBA

1790. Pennington, W. (1981). Records of a lake's life in time - the sediments. *Hydrobiologia* **79**, 197-219. FBA

1796. Reynolds, C.S., Jaworski, G.H.M., Cmiech, M.A., & Leedale, G.F. (1981). On the annual cycle of the blue-green alga Microcystis aeruginosa Kutz. emend. Elenkin. *Philosophical Transactions of the Royal Society (B)* **293**, 419-477. FBA

1857. Elliott, J.M. (1982). The effects of temperature and ration size on the growth and energetics of salmonids in captivity. *Comparative Biochemistry and Physiology (B)* **73**, 81-91. FBA

1901. Marker, A.F.H. & Casey, H. (1982). The population and production dynamics of benthic algae in an artificial recirculating hard-water stream. *Philosophical Transactions of the Royal Society (B)* **298**, 265-308. FBA

1911. Reynolds, C.S., Thompson, J.M., Ferguson, A.J.D., & Wiseman, S.W. (1982). Loss processes in the population dynamics of phytoplankton maintained in closed systems. *Journal of Plankton Research* **4**, 561-600. FBA

1917. Sutcliffe, D.W., Carrick, T.R., Heron, J., Rigg, E., Talling, J.F., Woof, C., & Lund, J.W.G. (1982). Long-term and seasonal changes in the chemical composition of precipitation and surface waters of lakes and tarns in the English Lake District. *Freshwater Biology* **12**, 451-506. FBA

1918. Talling, J.F. (1982). Utilization of solar radiation by phytoplankton. In *Trends in photobiology* (eds C. Helene, M. Charlier, T. Montenay-Garestier & G. Laustriat), pp. 619-631. Plenum, New York. FBA

1956. Davison, W. & Seed, G. (1983). The kinetics of the oxidation of ferrous iron in synthetic and natural waters. *Geochimica et Cosmochimica Acta* **47**, 67-79. FBA

1987. Jones, J.G., Gardener, S., & Simon, B.M. (1983). Bacterial reduction of ferric iron in a stratified eutrophic lake. *Journal of General Microbiology* **129**, 131-139. FBA

2016. Sutcliffe, D.W. (1983). Acid precipitation and its effects on aquatic systems in the English Lake District (Cumbria). *Report of the Freshwater Biological Association* **51**, 30-62. FBA

2046. Canter, H.M. & Heaney, S.I. (1984). Observations on zoosporic fungi of Ceratium spp. in lakes of the English Lake District; importance for phytoplankton population dynamics. *New Phytologist* **97**, 601-612. FBA

2075. Fryer, G. (1984). The conservation and rational exploitation of the biota of Africa's Great Lakes. In *Conservation of threatened natural habitats* (ed A.V. Hall), pp. 135-154. FBA

2175. Crisp, D.T. (1985). Effects of impoundment and regulation of the River Tees at Cow Green (Northern Pennines, U.K.) upon fish populations in afferent tributaries and in the river immediately downstream of the dam. In *Habitat modification and freshwater fisheries* (ed J.S. Alabaster), pp. 42-51. Butterworth, London. FBA

2188. Finlay, B.J. (1985). Nitrate respiration by protozoa (Loxodes spp.) in the hypolimnetic nitrite maximum of a productive freshwater pond. *Freshwater Biology* **15**, 333-346. FBA

2216. Maberly, S.C. (1985). Photosynthesis by Fontinalis antipyretica. I. Interaction between photon irradiance, concentration of carbon dioxide and temperature. *New Phytologist* **100**, 127-140. FBA

2246. Tett, P., Heaney, S.I., & Droop, M.R. (1985). The Redfield ratio and phytoplankton growth rate. *Journal of the Marine Biological Association of the United Kingdom* **65**, 487-504. FBA

2247. Tipping, E. (1985). Accumulation of humic substances in the hypolimnion of a seasonally anoxic lake following co-sedimentation with iron oxide. *Organic Geochemistry* **8**, 123-124. FBA

2259. Baker, J.H. & Orr, D.R. (1986). Distribution of epiphytic bacteria on freshwater plants. *Journal of Ecology* **74**, 155-165. FBA

2272. Chamier, A.C. & Willoughby, L.G. (1986). The role of fungi in the diet of the amphipod Gammarus pulex (L.): an enzymatic study. *Freshwater Biology* **16**, 197-208. FBA

2299. Fryer, G. & Talling, J.F. (1986). Africa: the FBA connection. *Report of the Freshwater Biological Association* **54**, 97-122. FBA

2328. Jones, J.G. & Simon, B.M. (1986). Nutritional strategy of a benthic filamentous bacterium. *Microbial Ecology* **12**, 323-330. FBA

2354. Reynolds, C.S. (1986). Experimental manipulations of the phytoplankton periodicity in large limnetic enclosures in Blelham Tarn, English Lake District. *Hydrobiologia* **138**, 43-64. FBA

2361. Talling, J.F. (1986). The seasonality of phytoplankton in African lakes. *Hydrobiologia* **138**, 139-160. FBA

2393. Carling, P.A. (1987). Bed stability in gravel streams, with reference to stream regulation and ecology. In *River channels. Environment and processes* (ed K. Richards), pp. 321-347. Blackwell, Oxford. FBA

2406. Crisp, D.T. (1987). Thermal "resetting" of streams by reservoir releases with special reference to effects on salmonid fishes. In *Regulated streams. Advances in ecology* (eds J.F. Craig & J.B. Kemper), pp. 163-182. Plenum, New York. FBA

2440. Le Cren, E.D. (1987). Perch (Perca fluviatilis) and pike (Esox lucius) in Windermere from 1940 to 1985; studies in population dynamics. *Canadian Journal of Fisheries and Aquatic Sciences (Supplement)* **44**, 216-228. FBA

2486. Atkinson, K.M. (1988). The initial development of net phytoplankton in Cow Green reservoir (Upper Teesdale), a new impoundment in Northern England. In *Algae and the aquatic environment* (ed F.E. Round), pp. 30-43. Biopress Ltd, Bristol. FBA

1990s

2708. Canter, H.M., Heaney, S.I., & Lund, J.W.G. (1990). The ecological significance of grazing on planktonic populations of cyanobacteria by the ciliate Nassula. *New Phytologist* **114**, 247-263. FBA/IFE

2711. Casey, H., Smith, S.M., & Clarke, R.T. (1990). Trends and seasonality in the nitrate concentrations and loads of the Bere Stream (Dorset) for the period 1966-1986. *Chemistry and Ecology* **4**, 85-94. IFE

2752. Ladle, M. (1990). Running waters: a conservationist's nightmare. In *The scientific management of temperate communities for conservation* (eds I.F. Spellerberg, F.B. Goldsmith & M.G. Morris), pp. 383-393. Blackwell, Oxford. IFE

2781. Saunders, J.R., Morgan, J.A.W., Winstanley, C., Raitt, F.C., Carter, J.P., Pickup, R.W., Jones, J.G., & Saunders, V.A. (1990). Genetic approaches to the study of gene transfer in microbial communities. In *Bacterial genetics in natural environments* (eds J.C. Fry & M.J. Day), pp. 3-21. Chapman & Hall, London. IFE/FBA

2787. Tipping, E. (1990). A model of surface water acidification in Cumbria and its uses in long-term research. *Freshwater Biology* **23**, 7-23. IFE

2872. Morgan, J.A.W., Winstanley, C., Pickup, R.W., & Saunders, J.R. (1991). Rapid immunocapture of Pseudomonas putida cells from lake water by using bacterial flagella. *Applied and Environmental Microbiology* **57**, 503-509. FBA/IFE

2876. Pickering, A.D., Pottinger, T.G., Sumpter, J.P., Carragher, J.F., & Le Bail, P.Y. (1991). Effects of acute and chronic stress on the levels of circulating growth hormone in the rainbow trout, Oncorhynchus mykiss. *General and Comparative Endocrinology* **83**, 86-93. IFE

2877. Pickup, R.W. (1991). Development of molecular methods for the detection of specific bacteria in the environment. *Journal of General Microbiology* **137**, 1009-1019. IFE

2952. Heaney, S.I., Corry, J.E., & Lishman, J.P. (1992). Changes of water quality and sediment phosphorus of a small productive lake following decreased phosphorus loading. In *Eutrophication: research and application to water supply* (eds D.W. Sutcliffe & J.G. Jones), pp. 119-131. Freshwater Biological Association, Ambleside. IFE

3002. Tipping, E. & Hurley, M.A. (1992). A unifying model of cation binding by humic substances. *Geochimica et Cosmochimica Acta* **56**, 3627-3641. IFE

3008. Winfield, I.J. (1992). Threats to the lake fish communities of the U.K. arising from eutrophication and species introductions. *Netherlands Journal of Zoology* **42**, 233-242. IFE

3046. Finlay, B.J. & Fenchel, T. (1993). Methanogens and other bacteria as symbionts of free-living anaerobic ciliates. *Symbiosis* **14**, 375-390. IFE

3078. May, L., Bailey-Watts, A.E., & Kirika, A. (1993). The ecology of Synchaeta kitina Rousselet in Loch Leven, Scotland. *Hydrobiologia* **255/256**, 305-315. IFE

3097. Reynolds, C.S. & Glaister, M.S. (1993). Spatial and temporal changes in phytoplankton abundance in the upper and middle reaches of the River Severn. *Archiv fur Hydrobiologie Supplementband* **101**, 1-22. IFE

3124. Wright, J.F., Furse, M.T., & Armitage, P.D. (1993). RIVPACS - a technique for evaluating the biological quality of rivers in the U.K. *European Water Pollution Control* **3**, 15-25. IFE

3141. Baroudy, E. & Elliott, J.M. (1994). The critical thermal limits for juvenile Arctic charr Salvelinus alpinus. *Journal of Fish Biology* **45**, 1042-1053. IFE

3158. Elliott, J.M. (1994). *Quantitative ecology and the brown trout*. Oxford Univ.Press, Oxford, xi+286p. IFE

3203. Reynolds, C.S. (1994). The ecological basis for the successful biomanipulation of aquatic communities. *Archiv fur Hydrobiologie* **130**, 1-33. IFE

3250. Canter-Lund, H. & Lund, J.W.G. (1995). *Freshwater algae: their microscopic world explored*. Biopress Ltd, Bristol, 376p. FBA

3286. George, D.G. & Taylor, A.H. (1995). UK lake plankton and the gulf stream. [letter]. *Nature* **378**, p139. IFE

3295. House, W.A., Denison, F.H., & Armitage, P.D. (1995). Comparison of the uptake of inorganic phosphorus to a suspended and stream bed-sediment. *Water Research* **29**, 767-779. IFE

3420. Maberly, S.C. (1996). Diel, episodic and seasonal changes in pH and concentrations of inorganic carbon in a productive lake. *Freshwater Biology* **35**, 579-598. IFE

3498. Finlay, B.J., Maberly, S.C., & Cooper, J.I. (1997). Microbial diversity and ecosystem function. *Oikos* **80**, 209-213. IFE

3539. Marker, A.F.H. & Collett, G.D. (1997). Spatial and temporal characteristics of algae in the river Great Ouse. I. Phytoplankton. *Regulated Rivers Research and Management* **13**, 219-233. IFE

3553. Pinder, L.C.V., Marker, A.F.H., Pinder, A.C., Ingram, J.K.G., Leach, D.V., & Collett, G.D. (1997). Concentrations of suspended chlorophyll a in the Humber rivers. *Science of the Total Environment*, **194/195**, 373-378. IFE

3626. Elliott, J.M. & Hurley, M.A. (1998). A new functional model for estimating the maximum amount of invertebrate food consumed per day by brown trout, Salmo trutta. *Freshwater Biology* **39**, 339-349. IFE

3644. George, D.G. & Hewitt, D.P. (1998). The influence of year-to-year changes in position of the Atlantic Gulf Stream on the biomass of zooplankton in Windermere North Basin, UK. In *Management of lakes and reservoirs during global climate change* (eds D.G. George, J.G. Jones, P. Puncochar, C.S. Reynolds & D.W. Sutcliffe), pp. 223-244. Kluwer Academic Publishers, Dordrecht. IFE

3654. House, W.A. & Warwick, M.S. (1998). Intensive measurements of nutrient dynamics in the River Swale. *Science of the Total Environment* **210/211**, 111-137. IFE

3710. Talling, J.F. & Lemoalle, J. (1998). *Ecological dynamics of tropical inland waters*. University Press, Cambridge, 452p. FBA

3746. Elliott, J.M. & Hurley, M.A. (1999). A new energetics model for brown trout, Salmo trutta. *Freshwater Biology* **42**, 235-246. IFE

3747. Finlay, B.J. & Clarke, K.J. (1999). Ubiquitous dispersal of microbial species. *Nature* **400**, p828. IFE

3761. House, W.A. & Warwick, M.S. (1999). Interactions of phosphorus with sediments in the River Swale, Yorkshire, UK. *Hydrological Processes* **13**, 1103-1115. IFE

3791. Saxby-Rouen, K.J., Leadbeater, B.S.C., & Reynolds, C.S. (1999). The relationship between the growth of Synura petersenii (Synurophyceae) and components of the dissolved inorganic carbon system. *Phycologia* **37**, 467-477. IFE

2000–2006

3828. Casper, P., Maberly, S.C., Hall, G.H., & Finlay, B.J. (2000). Fluxes of methane and carbon dioxide from a small productive lake to the atmosphere. *Biogeochemistry* **49**, 1-19. CEH

3839. Elliott, J.M., Hurley, M.A., & Maberly, S.C. (2000). The emergence period of sea trout fry in a Lake District stream correlates with the North Atlantic Oscillation. *Journal of Fish Biology* **56**, 208-210. CEH

3880. Reid, V.A., Carvalho, G.R., & George, D.G. (2000). Molecular genetic analysis of Daphnia in the English Lake District: species identity, hybridisation and resting egg banks. *Freshwater Biology* **44**, 247-253. CEH

3887. Reynolds, C.S. & Irish, A.E. (2000). *The phytoplankton of Windermere (English Lake District)*. Freshwater Biological

Association, Ambleside, 73p. CEH

3919. Elliott, J.A., Reynolds, C.S., & Irish, A.E. (2001). An investigation of dominance in phytoplankton using the PROTECH model. *Freshwater Biology* **46**, 99-108. CEH

3938. Hilton, J. (2001). Radionuclide dispersion in freshwaters. In *Radioecology, radioactivity and ecosystems* (eds E. Van der Stricht & R. Kirchmann), pp. 221-237. International Union of Radioecology, Liege. CEH

3942. House, W.A., Duplat, D., Denison, F.H., Dawson, F.H., Cooper, D.M., May, L., & Henville, P.M. (2001). The role of macrophytes in the retention of phosphorus in the River Thame, England. *Chemistry and Ecology* **17**, 271-291. CEH

3977. Rouen, M.A., George, D.G., & Hewitt, D.P. (2001). Using an automatic monitoring station to assess the impact of episodic mixing on the seasonal succession of phytoplankton. *Verhandlungen der Internationalen Vereinigung fur Theoretische und Angewandte Limnologie* **27**, 2972-2976. CEH

4010. Cooper, D.M., House, W.A., May, L., & Gannon, B. (2002). The phosphorus budget of the Thame catchment, Oxfordshire, UK:1. mass balance. *Science of the Total Environment* **282-283**, 233-251. CEH

4017. Elliott, J.M. (2002). The drift distances and time spent in the drift by freshwater shrimps, Gammarus pulex, in a small stony stream, and their implications for the interpretation of downstream dispersal. *Freshwater Biology* **47**, 1403-1417. FBA

4079. Talling, J.F. & Parker, J.E. (2002). Space-time configurations of solute input and biological uptake in river systems traversing limestone uplands (Yorkshire Dales, northern England). *Hydrobiologia* **487**, 153-165. FBA/CEH

4080. Talling, J.F. & Parker, J.E. (2002). Seasonal dynamics of phytoplankton and phytobenthos, and associated chemical interactions, in a shallow upland lake (Malham Tarn, northern England). *Hydrobiologia* **487**, 167-181. FBA/CEH

4082. Tipping, E. (2002). *Cation binding by humic substances*. University Press, Cambridge, 421p. CEH

4083. Tipping, E., Bass, J.A.B., Hardie, D., Haworth, E.Y., Hurley, M.A., & Wills, G. (2002). Biological responses to the reversal of acidification in surface waters of the English Lake District. *Environmental Pollution* **116**, 137-146. FBA/CEH

4106. Clarke, R.T., Wright, J.F., & Furse, M.T. (2003). RIVPACS models for predicting the expected macroinvertebrate fauna and assessing the ecological quality of rivers. *Ecological Modelling* **160**, 219-233. CEH

4107. Clegg, M.R., Maberly, S.C., & Jones, R.I. (2003). Behavioural responses of freshwater phytoplanktonic flagellates to a temperature gradient. *European Journal of Phycology* **38**, 195-203. CEH

4111. Elliott, J.M. (2003). Interspecific interference and the functional response of four species of carnivorous stoneflies. *Freshwater Biology* **48**, 1527-1539. FBA

4136. Madsen, T.V. & Maberly, S.C. (2003). High internal resistance to CO2 uptake by submerged macrophytes that use HCO3-: measurements in air, nitrogen and helium. *Photosynthesis Research* **77** 183-190. CEH

4163. Talling, J.F. (2003). Phytoplankton-zooplankton seasonal timing and the 'clear-water phase' in some English lakes. *Freshwater Biology* **48**, 39-52. FBA

4264. Butterwick, C., Heaney, S.I., & Talling, J.F. (2005). Diversity in the influence of temperature on the growth rates of freshwater algae, and its ecological relevance. *Freshwater Biology* **50**, 291-300. FBA

4291. Hewitt, D.P. & Sweeting, R.A. (2005). Long-term data sets on Windermere. *Annual Report of the Freshwater Biological Association* **73**, 43-45. FBA

4300. Larsson, S., Forseth, T., Berglund, I., Jensen, A.J., Naslund, I., Elliott, J.M., & Jonsson, B. (2005). Thermal adaptation of arctic charr: experimental studies of growth in eleven charr populations from Sweden, Norway and Britain. *Freshwater Biology* **50**, 353-368. FBA

4394. Reynolds, C.S. (2006). *The ecology of phytoplankton*. Cambridge University Press, Cambridge. FBA/CEH