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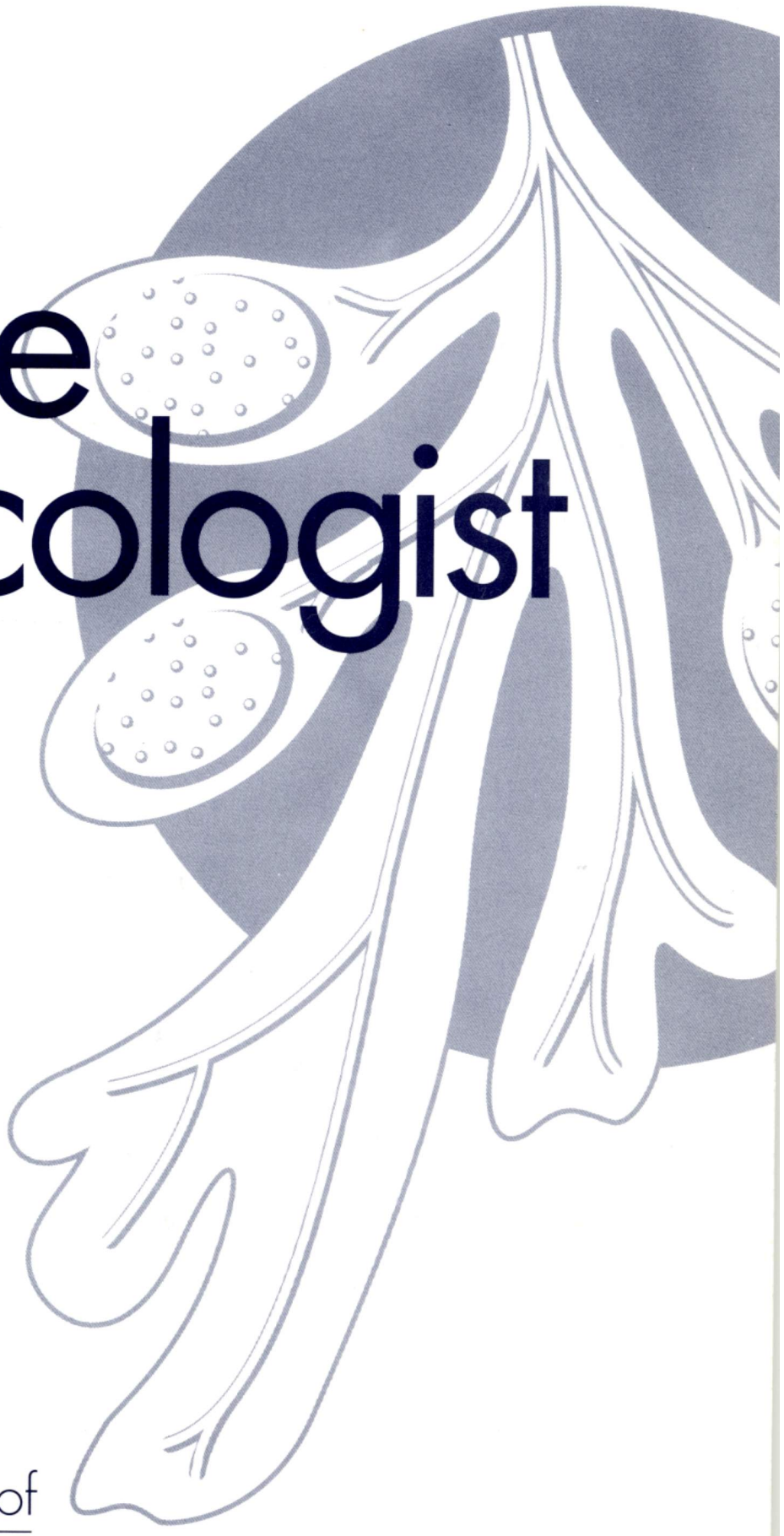

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BIODIVERSITY AND CONSERVATION: AN ALGAL PERSPECTIVE

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INTRODUCTION

Biodiversity has moved rapidly up the scientific and political agenda along with ozone depletion and greenhouse warming of the Earth's atmosphere to become one of the key issues of the 1990s. The term was coined first in the early 1980s as a contraction of 'biological diversity' and, in its broadest sense, embraces the total variety of life on Earth for which it is often loosely considered a synonym. It includes a number of fundamental and hierarchically related levels, from the molecular and genetic through to ecosystems, landscapes and, ultimately, to the biosphere itself. In 'The Convention on Biodiversity' document signed at the Rio Earth Summit in 1992, it is defined as 'The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems'. An important component of biodiversity is functional diversity, a term that refers to the variety of biological processes or functions of a particular ecosystem. The definition of biodiversity and the level at which research should be conducted (e.g., gene, species, higher taxa, functional, groups) depends on the scientific questions to be addressed. For the purpose of the present account I have focused on species and, to a much lesser extent, habitat diversity as the two are inextricably linked.

The high scientific and political priority given to biodiversity is largely driven by conservation issues, particularly concern being felt over the precipitous decline in biodiversity brought about by human activities. As a consequence there are many species living today that will be lost before they are discovered. Impoverishment of biological systems through loss of diversity at all levels reduces their resilience so making them unable to adapt to further environmental change. The biodiversity debate has tended to focus on tropical forest vegetation, generally acknowledged as one of the most biologically diverse and threatened of the world's ecosystems. Increasingly, attention needs to be given to aquatic biodiversity in view of the importance of major feed-back mechanisms centred in the oceans, including the global heat balance affected by the growth of planktonic algae. The phytoplankton influence it through the carbon cycle and increase in cloud cover caused by dimethyl sulphide production which in aerosol form acts as nuclei for cloud formation. Already the functional integrity of major marine systems including coral reefs (Gleason & Wellington, 1993), the most complex of marine ecosystems and the counterpart of the tropical forest, is becoming increasingly threatened.

The intention of introducing the topic of algal biodiversity is to place it in the context of recent biodiversity initiatives, to summarise our current understanding of its magnitude, and to consider how its understanding can serve to underpin decisions on conservation and management of species and habitats. In no way is the account intended to be anything like comprehensive, rather it focuses selectively on a few key areas of algal biodiversity and conservation.

BIODIVERSITY INITIATIVES

Loss of biodiversity is no longer solely the concern of scientists, as governments and the public are becoming increasingly aware of the 'biodiversity crisis' and the urgent need to address it. Scientists are expected to provide answers to such questions as 'what is the scale of the crisis?', 'why does a reduction matter?', 'what are its causes?', 'what can do be done to prevent it?' and 'how should priorities for its protection be established?'. Satisfactory answers to these and similar questions are not possible until such time as biodiversity research provides the necessary data and scientific proofs. In response to the need to provide accurate scientific information about the Earth's reservoir of species, institutions and agencies have organised workshops and conferences to debate biodiversity issues, define priority areas for future research, and draw up action plans. Of these meetings some of the most significant have been those organised by the United Nations, the Scientific Committee on Problems of the Environment (SCOPE), the International Union of Biological Sciences (IUBS), and the International Union of Microbiological Societies (IUMS).

The United Nations conference on 'Environment and Development' (UNCED) was held in June 1992 at Rio de Janeiro (see Grubb et al., 1993). What led to 'Rio Earth Summit' was recognition by the world's leaders that in order to ensure continued economic development it is essential to maintain the integrity of our natural heritage through concerted action. Various commitments were entered into at the Summit including the signing of a global action plan, Agenda 21, a document giving political commitment to the integration of environmental concerns and calling for increased understanding of global biodiversity. A key component of Agenda 21 was 'The Convention on Biological Diversity', which has as one of its principal objectives 'to conserve the maximum possible biological diversity for the benefit of present and future generations and for its intrinsic values'. Since the Summit several plans, programmes, and strategies have been drawn up designed to meet the challenge of understanding biodiversity, one of which is a programme of discovery and research proposed by the international systematic community and known as 'Systematics Agenda 2000: Charting the Biosphere' (1994). Agenda 2000 puts forward radical proposals for an accelerated programme of documenting and describing the world's biodiversity over the next 25 years. The expectation is that the knowledge so derived will be organised into databases and predictive classifications to be used to understand, maintain, and sustainably use the world's biodiversity. In order to publicise and advance Agenda 2000, symposia were held in London at The Royal Society in London on 12 April 1994, and three days later in Paris at the Societe Francaise de Systematique; the intention is to publish the proceedings of the London meeting in a special issue of 'Biodiversity and Conservation'.

Article 6A of 'The Convention on Biological Diversity' states that signatories are expected 'to develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity'. As part of the United Kingdom government's commitment to the Convention, the 'Darwin Initiative for the Survival of Species' was launched and in January 1994 'Biodiversity The UK Action Plan' was published. The 'Action Plan' maps out strategies and programmes for the conservation and sustainable use of biological diversity in the United Kingdom and Dependent Territories until the end of the century. A month prior to publication of the Action Plan various voluntary conservation-linked organisations produced 'Biodiversity Challenge: an Agenda for Conservation Action in the UK' (Biodiversity Challenge, 1993), a consultative document outlining what generic actions they considered essential for conserving biodiversity in the United Kingdom. One of the principal criticisms of the Action Plan is the omission of specific conservation targets giving completion dates. According to Pearce (1944), specific and time-tabled targets for Britain's Dependent Territories were included in a draft version but were omitted from the published Action Plan. What is common to the myriads of reports, books and other texts published in the 1980s on the extent, importance, causes, maintenance and conservation of biodiversity is the overwhelming attention given to terrestrial systems, and the simultaneous neglect of microorganisms.

Microbial Biodiversity

A workshop on 'Ecosystem Function of Biological Diversity' held at Washington in June 1989 (Di Castri & Younes, 1990) was one of the first biodiversity meetings to draw particular attention to the neglect of microorganism diversity. It recognised there to be an urgent need to establish a programme of research on the functional diversity of microorganisms in view of their vital role in the maintenance of the Earth's ecosystems and biosphere. In this and following meetings on microbial biodiversity, the term microorganism is taken to encompass algae, fungi (including yeasts), lichens, protozoans, bacteria (including cyanobacteria) and viruses. It is defined by Hawksworth & Ritchie (1993) as 'organisms which either belonging to phyla many members of which either cannot be seen by the unaided eye, or where microscopic examination, and in many cases growth in pure culture, is essential for their identification'. It appears that about 52 of the world's 95 phyla of living organisms fall within this concept of a microorganism.

The Washington meeting was followed by a series of biodiversity workshops to discuss the development of a programme to set directions for future tasks to be accomplished (see Hawksworth & Colwell, 1992). The first on 'Biodiversity amongst Microorganisms and its Relevance' was at Amsterdam in 1991; its proceedings were published the following year in the first volume of 'Biodiversity and Conservation'. It endorsed a decade of microbial studies, Microbial Diversity 21,

among whose objectives was a call for the establishment of a global inventory within the general framework of systematics and ecology. Outlined were actions required to improve our knowledge of microbial diversity and of the importance of microorganisms in ecosystem function. Microbial Diversity 21 is designed to dovetail with other programmes including Diversitas, a programme known as 'Ecosystem Function and Biodiversity' when first launched in 1990 under the joint sponsorship of IUBS, SCOPE, the International Council of Scientific Unions (IUNC) and UNESCO. Diversitas spawned a series of workshops on biodiversity and related topics (e.g., 'Biodiversity and Global Change', see Solbrig et al., 1992), including the one that led to 'Microbial Diversity 21'. In another of these workshop held in August 1993 at Royal Holloway and Bedford New College, Egham on 'Microorganisms and the Maintenance of Biodiversity' (Hawskworth, 1994), algae were the only important microbial group not considered. These and other initiatives on microbial biodiversity are discussed in more detail by Hawksworth & Ritchie (1993).

Marine Biodiversity

Few of the works published in the 1980s on biodiversity and related issues gave more than passing mention to aquatic ecosystems. The neglect of marine biodiversity was addressed specifically at a meeting of the IUBS, IABO, UNESCO Task Force on Programme Development held in 1990. A report on 'Marine Biodiversity and Ecosystem Function' by Grassle et al. (1991) summarised the main conclusions of this and other meetings dealing with marine biodiversity issues. One of the principal aims of the report was 'to initiate an international comparative research programme on biological diversity in the context of the structure and function of ecosystems and of global comparative biogeography'. In the same year a meeting at the Smithsonian Institution in Washington, D.C. concluded that man's activities were threatening the biodiversity of all marine systems (see Norse, 1991). Since 1990 interest in marine biodiversity has been gathering pace and a number of reports and texts have been published recently including 'Global Marine Biological Diversity: a Strategy for Building Conservation into Decision Making' (Norse, 1993), a companion document to the 'Global Biodiversity Strategy' (Courrier, 1992) that aimed to provide concrete guidelines for action in the conservation and sustainable use of biological diversity. As a contribution to the 'Strategy', the World Conservation Monitoring Centre (WCMC) in Cambridge produced a source book of biodiversity (Groombridge, 1992) that includes a resume of information on algae under 'Lower Plant Diversity'. Other important initiatives were a series of IUBS workshops on different systems (e.g., 'Lagoons, Estuaries and Mangroves'), a workshop at Plymouth in March 1993 to discuss UK marine biodiversity priorities, and another at Denver, Colorado in March 1993 on 'Biological Diversity in Marine Systems (BioMar)'. A symposium on 'Algal Ecology and Biodiversity in the Tropics' and a workshop 'Algal Biodiversity' were held during the 5th International Phycological Congress that took place in China from 26 June to 2 July 1994. Opinions exchanged during the workshop panel discussion were used in determining the views of the membership of the International Phycological Society on a variety of biodiversity issues that relate to algae. These views were taken to the 25th General Assembly of the IUBS and the International Forum entitled 'Biodiversity: Science and Development - Towards a New Partnership' (Paris, 5-9th September) by a representative of the Society. Another meeting on marine biodiversity, 'Marine Biodiversity: Causes and Consequences', took place at the University of York between 30th August and 2nd September 1994. These represent just a few of the many initiatives currently underway.

SPECIES DIVERSITY

The species is the commonest and most practical taxonomic unit used when describing, cataloguing and measuring the extent and state of biodiversity. Species diversity and biodiversity are sometimes considered to be synonymous, with species generally regarded as the most natural level for considering whole-organism diversity. One of the problems of using species is that all units of classification above the gene are artificial. There is therefore some disagreement as to how to take account of diversity at different taxonomic levels when it is impossible to define with any real precision units such as species. Analysis of species diversity often involves comparing units that are not necessarily equivalent because species concepts are not equivalent. The whole question of species as the units of biodiversity is to be addressed at a symposium entitled 'The Units of Biodiversity - Species in Practice and Theory' that is to be held next April at Cardiff University.

Estimates of algal biodiversity are bedeviled by problems associated with the non-equivalence of species concepts, the unresolved status of the many inadequately described species, and by the paucity of information since so much of the world remains phycologically-unexplored. Species belonging to eight classes are defined solely on morphological features ('morphospecies') as the biological species concept cannot apply where sexual reproduction has yet to be observed. Andersen (1992) comments thus 'consistent species concepts can be found within smaller algal groups but no single concept can be applied to all algal groups'. Despite all these problems species biodiversity patterns, linked to their cause and maintenance, often provides the scientific underpinning to policy decisions regarding pollutant and waste disposal, fisheries management, habitat alteration, and the conservation and preservation of aquatic resources.

Simple counts of species (species richness) are one of the most frequently used measure of biodiversity. In order to compare diversity in biological communities ecologists have developed mathematical indices to express the relationship between species richness and information on their relative abundance or evenness. In conservation evaluations the various indices used are frequently weighted to some degree. One of these indices takes account of the number of higher taxa so emphasis is placed on the degree of difference between taxa. It is important to take account of the level of organisms in the hierarchy since those differing widely from each other contribute more to overall diversity than sibling species. An area or site containing species representing different higher taxa thus shows greater taxonomic diversity than a more species rich one with fewer higher taxa. Taxonomic diversity measurements either attempt to measure genetic differences directly, or indirectly through the taxonomic hierarchy. Of the phenetic, phylogenetic and cladistic approaches considered by Williams & Humphries (1994) for measuring the degree of difference between species, the approach using cladistics was considered the most appropriate.

Various approaches have been used to formulate ideas on the extent and pattern of species diversity, one of the most commonly adopted being to seek the opinions of taxonomic specialists in particular groups (see Gaston, 1991). Overall species diversity has been predicted using empirical relationships concerning the structure of food webs, numbers of parasitic or other symbiotic species typically associated with 'hosts' (see May, 1990; Hammond, 1992). Another approach takes account of the rate at which new species have and are being described, and uses the information to calculate estimates of likely numbers of species still to be described. In determining the rate of increase account has to be taken of those species that disappear into synonymy; an appreciable number when it is considered that only about 40,000 out of 200,000 proposed algal species names are currently accepted (Hawksworth & Greuter, 1989). Time-series data are often more a reflection of overall taxonomic activity. So far the approach has had only limited predictive value when applied to better-known groups (e.g., birds and mammals), otherwise proving singularly unsuccessful for determining global species-richness of major groups.

ESTIMATES OF BIODIVERSITY

Global Biodiversity

One of first steps in understanding ecosystem integrity and functioning is to discover, describe and make an inventory of the species present. A task scarcely begun with knowledge remaining woefully inadequate except for a small number of major groups. Birds and mammals are two of the exceptions in which most species have been described and a considerable body of information exists on their geographical distribution patterns, reproductive biology, ecology and abundance. More typical is the situation regarding microorganisms and invertebrates where estimates of known species vary from 5-10% of the total, and the majority are based on descriptions of a single or very few collections. World totals arrived at through taxonomic literature searches indicate the number of species currently described to be around 1.4-1.8 million (Hammond, 1992), the majority of which are insects. Estimates of the numbers of species still to be discovered range from just 2 million to 30 million or more. In many of lesser known groups, the large majority of species are likely to disappear before they are discovered if current estimates of extinction rates are correct. Even in birds and mammals, it is estimated that present extinction rates are 100 to 1,000 times greater than the 'natural' background rate. Predictions of future extinction rates are frequently derived from species-area

relations combined with projected rates of destruction of area of habitat. If current deforestation trends continue it has been estimated that 5 to 10 percent of the world's species will be lost per decade over the next 30 years. This would amount to a potential loss of 50,000 to 100,000 species per year if we accept the estimated total of species on earth to be 10 million; a rate unparalleled since the great spasms of extinction in the geological past (see Bibby et al., 1992).

Aquatic Biodiversity

Ideas of aquatic species diversity have been radically altered following recent studies by Grassle & Maciolek (1992) on the species richness of deep-sea communities. They estimate the numbers of undescribed macro-benthic species associated with deep-sea sediments to lie between 1 and 10 million. Should these estimates prove correct then aquatic biodiversity might rival or even surpass that on land. Unquestionably phyletic diversity is significantly higher in the aquatic environment, with 28 of the 33 phyla (88%) in the animal kingdom being marine of which 13 are exclusively marine compared to 11 phyla exclusively terrestrial (see Angel & Rice, 1993). Reasons put forward for the greater taxonomic diversity of the oceans include their vast size, topographic complexity, presence of vast systems based wholly on chemosynthesis, and systems and 'life styles' of major importance without terrestrial analogues e.g., filter-feeders, nekton, under-ice ecosystems. In terms of inhabited volume the marine environment is at least 200 times greater and the average biomass 1000 times greater than that on land. Recent estimates indicate that aquatic algae and cyanobacteria fix an amount of carbon almost equivalent to that fixed by all terrestrial systems (see Thorne-Miller & Catena, 1991).

Algal Biodiversity

To raise the consciousness of scientists regarding algal biodiversity, Andersen (1992) has attempted to estimate algal biodiversity using the species as the basic unit of measurement. He treated the algae as a single group distinct from the Protists or Protoctists whilst recognising that eukaryotic algae are divisible into at least seven distinct lineages. In arriving at numbers of described and undescribed species Andersen sought the opinion of taxonomists specialists. While these specialists were able to assert with some confidence the number of currently recognised taxa, global estimates of undescribed species were highly speculative 'guess estimates'. Not surprisingly estimates were rarely in complete agreement and some varied widely. For example, estimates of unknown diatom species ranged from 10,000-10 million with the larger figure reflecting the views of those who consider that physiological races should be afforded species status. A greater reliance can be placed on estimates of some of the better-known groups (e.g., stoneworts and seaweeds) whose members are generally macroscopic.

The generic names of algae are included in the list of over 28,000 in 'Names in Current Use for Extant Plant Genera' (Greuter et al., 1993). No similar compilation exists of currently recognised subgeneric taxa and so various contemporary taxonomic sources were consulted when arriving at totals for numbers of known species of eukaryotic algae (Tables 1, 2). The figure of ca. 36,000 species represents about 17% of those predicted as existing today based on the opinions of taxonomic specialists that were collated by Andersen (1992). Earlier estimates of unknown algal species were considerably more conservative (see Table 1, for figures cited by Hawksworth, 1991), probably reflecting the reluctance of those consulted to take account of anything but incontrovertible evidence. Comparative figures are given in Table 3 for plant groups and other groups of microorganisms. It appears that some of the least known groups are likely to be the most species-rich. If the estimate of 10 million unknown species of diatoms were to be included then algae would be the least known of the groups of microorganism. According to Hammond (1992), the algae form about 2.4% of currently-known species belonging to all the major groups and is estimated at ca. 1.7 million.

BIODIVERSITY AND CONSERVATION

There are three principal approaches to marine conservation: regulation and management of individual activities, creation of small marine protected areas, and the establishment of large, multiple-use protected areas with integrated management. Almost invariably habitats rather than species are the focus of conservation efforts in the marine environment. In protecting representative samples of ecosystems or important habitats, the assumption is made that all the species inhabiting them will also be protected. Statutory protection in the United Kingdom focuses on the following types of protected area: SSSIs (applies only down to low water), Marine Consultation Areas (only operating in Scotland), Marine Nature Reserves and Special Areas of Conservation (SACs) under the European Community Directive known as the 'Council Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora' (not fully effective until turn of century). The 'Marine Nature Conservation Review' is providing the essential site-related information on habitats and communities required to assess the nature conservation importance of particular species and sites, and indicate the potential for damage through human activity. Information on seaweeds and invertebrate animals is used for selecting outstanding examples of wildlife and natural habitats for protection. Unquestionably conserving algal biodiversity is best served by ensuring the preservation of the widest range of least disturbed habitat types.

Freshwater biodiversity is seriously threatened world-wide as programmes designed to protect it have seriously lagged behind those for saving terrestrial biota. Distribution patterns are fundamentally different from those in marine and terrestrial systems since freshwater habitats are relatively discontinuous. The physical separation has the consequence that freshwater biodiversity is often localised, species are unable to adjust their ranges in response to ecological and climatic change, and considerable variation in diversity might exists within a region because of individual site differences (see Global Biodiversity Strategy, 1992). Lakes and similar water bodies are to be regarded as 'habitat islands' and the larger, more ancient ones harbour some of the world's greatest concentrations of locally endemic species.

Undesirable biological changes are increasingly affecting the conservation status not only of lakes, ponds, canals and rivers but also of estuarine and coastal environments. In most freshwater systems, conservation often amounts to making the best of what is left since most of them in the more developed world are heavily impacted upon by man. Threats to biodiversity of aquatic systems include physical destruction, habitat modification, over-exploitation, biological invasions, global climatic change, chemical and thermal pollution, acidification, and nutrient-enrichment or eutrophication. Nutrient enrichment is of particular concern in freshwater habitats, estuaries and shallow coastal regions where it causes excessive algal growths that lead to a decline in biodiversity and a reduction in amenity value and a consequent change in conservation status. Species are occasionally used to prioritise sites or areas for conservation, the principal justification relating to the rarity and perceived threat to charismatic or 'high profile' species (otters, dragonflies, birds) and those of actual or perceived resource value (game birds or fish). Algae are certainly not charismatic and so inadequate is the information that it is impossible to know whether any should be classified as endangered with the exception of stoneworts. Sufficient knowledge exists on the distribution and conservation status of this freshwater group to accord them Red Data Book status in Britain and Ireland (see Stewart & Church, 1992), and for them to appear in Red Lists covering Finland, Poland and Germany. No evidence exists to suggest that the stoneworts are under threat globally or of any algae having become extinct in recent times.

Taxonomic inventories enable the conservation status of areas to be evaluated, and data on patterns and processes controlling biodiversity are crucially-important for their management. The need to take account of algae is not just because of their key role in the functioning and maintenance of biodiversity, but also because they represent an unexploited genetic resource. Various reasons have been put forward as why to so little consideration has been given to algae in conservation assessments including: absence of information concerning species at important sites, lack of information on rarity of individual species, imprecise understanding of the ecological requirements of species, length of time and labour-intensiveness of producing accurate inventories, and lack of taxonomic expertise and literature for accurate identification. Much of the neglect of algae in both conservation biology and biodiversity debates reflects the inadequacy of our knowledge of their taxonomy due, in part, to the present dearth of systematists specialising in the group.

Setting Conservation Priorities

The effective targeting of limited resources requires the setting of conservation priorities often using the existing knowledge base however inadequate it might be. Species diversity is one of a number of criteria used to identifying sites or areas of conservation importance. Others include size, naturalness, rarity, fragility, representativeness, distinctiveness, recorded history, position in an ecological/geographical unit, potential value, likelihood of success, and intrinsic appeal. Unlike on land, conservation efforts in the aquatic environment tend to be directed more towards habitats rather than individual species and their diversity, rarity and taxonomic distances (phyletic diversity). If information was available then another conservation criterion that might be taken into account would be the extent to which the function of the ecosystem becomes impaired by a reduction in species richness. If all other things are equal, an efficient approach is to give priority to safeguarding species-rich sites or habitats, often referred to as centres or 'hotspots' of diversity (see Myers, 1990). It is a species rather than habitat-orientated approach and is rather less radical than the single-species management one being explored by many ecologists.

Various conservation programmes (e.g., IUCN Plant Conservation Programme) support projects aimed at identifying centres of high biodiversity and endemism (Vane-Wright, 1992). These centres need to be relatively small areas that contain within them an inordinately large share of diversity which, if protected, would safeguard a significant proportion of national or world biodiversity. In deciding which to designate protected areas for conservation it would be easier and more effective if the following were true: habitats that are species-rich for one group of organisms are also species-rich for others, and rare species occur in them and therefore benefit from the conservation of species-rich habitats. Studies have been carried out to discover whether species-rich areas for one group coincide with major or multiple species-rich areas of other taxa, and what proportion of a species pool might be conserved by setting aside a limited number of reserves. An analysis of data sets for the British fauna and flora by Prendergast et al. (1993) provided only weak support for the notion that protecting a species-rich area for one or two groups effectively conserves rare groups and those of restricted distribution. As a result they cautioned against basing reserve selection on species richness and rarity in parts of the world where distribution data are often sparse and mapped at a large scale. In temperate regions, such as the British Isles where species diversity is relatively low, a few species-rich areas are more likely to encompass a large share of the diversity of a group compared to the tropics. Nonetheless, the possibility exists that a greater co-incidence exists in the tropics of both hotspots for different taxonomic groups and hotspots for rare taxa due to the coarser scale of resolution, greater species richness, and more limited geographical ranges of individual species. Another approach is to place the emphasis on the numbers of endemics present rather than upon species richness. Such an approach is adopted when considering threatened island floras that frequently contain a high proportion of endemics.

The concept of 'complementarity', and its application in critical faunas evaluation or distributional analysis (see Ackery & Vane-Wright, 1984), is an objective and systematic approach to conservation planning. Given that one of the aims of conservation is to safeguard as full a species complement of a taxonomic group as possible, critical 'faunas' analysis addresses the question 'what is the minimum set of areas which would contain at least one viable population of every species?' The critical set is identified by selecting a high diversity site and then successively choosing additional sites which contain the greatest number of species not represented previously. A satisfactory approach at the regional level but considered insufficiently flexible for global conservation planning.

Hotspots of Algal Diversity

To recognise centres of biodiversity requires reasonably complete and accurate species inventories covering the major algal groups. Knowledge of broad geographical scale species diversity patterns is limited by the inadequacy of authoritative inventories with the exception of seaweeds and stoneworts. In a global analysis of seaweed floras, Tittley (1992) and Bolton (1994) consider those of the Japanese Pacific region, parts of South East Asia, the tropical and subtropical western Atlantic, Mediterranean, and the temperate regions of the North East Atlantic to be the most diverse. Other

moderately diverse seaweed floras are those of Chile, North-West America, California and tropical East Africa (principally South Africa). In the North-East Atlantic, even allowing for variations in the intensity of collecting, marked differences in species richness are evident with the coasts of the British Isles, Atlantic France and northern Spain, and the Canaries (Alvarez et al., 1988) being species hotspots. The influence of geography on species diversity has long been apparent in island settings where the number of species tend to increase with island size and decrease with distance from sources of colonisers (MacArthur & Wilson, 1967). Small and isolated islands are usually cold spots of seaweed diversity reflecting their small coastline, often recent age and problems of long-distant dispersal. Such islands are extremely important in conservation terms if they contain many threatened endemic species. However seaweed endemism is often low on these islands compared to that for land plants. For example, only one out of 61 seaweeds recorded from St. Helena are endemic (Lawson et al., 1993) whereas 50 out of 70 species of native flowering plant are endemic (see Pearce, 1994). Endemism is considered particularly high on long isolated continents (Australia) and water masses isolated from the main ocean basins i.e., the Mediterranean and Caspian Sea.

Most of the evidence to date indicates species diversity of seaweeds to be greater in temperate than tropical regions. Coral reefs are still hotspots of overall biodiversity in otherwise nutrient-poor and unproductive tropical pelagic areas. These highly productive centres of biodiversity still owe their existence to endosymbiotic algae living within stony corals and cementation by crustose coralline algae. Besides coral reefs and deep-sea sediments other centres of endemism and diversity are long stable, geologically ancient lakes such as Baikal and Biwa (see Pollinger, 1990). No single theory successfully explains the high diversity encountered in what appear to be relatively stable ecosystems.

Attempts to analyse regional distribution patterns of better-known groups of microalgae (e.g., diatoms and desmids) have focused on biogeographical relationships rather than endemism or species diversity. Only in the stoneworts has the distributional information been sufficiently complete to enable a preliminary global analysis of species diversity patterns (John, 1992). For conservation purposes information is required on a more local and regional scale to enable sites or areas of high and low species richness to be recognised.

Conserving Algal Diversity

In addition to ethical reasons, the most convincing one for protecting algal diversity relates to their crucial importance in maintaining the functional integrity of aquatic systems. Often systems dominated by microalgae have high species diversity, but knowledge is lacking concerning the relationship between efficiency or resilience and species diversity. The degree of resilience is dependent on the number of functional analogues within a functional group i.e., the level of redundancy or congeneric homeotaxis. Such redundancy within a functional group endows an ecosystem with increased resilience to perturbations since species with similar functions are capable of replacing one another; this 'bootstrapping' buffer is believed to contribute to the success of many microbial-dominated ecosystems. One of the principal gaps in our knowledge is not knowing the extent to which ecosystem function is impaired by a reduction in species richness. What needs to be addressed is how the loss or addition of species that perform the same function affects both community structure and resilience. Once an alga performing a 'key' role is affected then a dramatic change might be expected, often such algae have been termed 'keystone species' in recognition of their crucial role. To identify keystone organisms is critically-important since they can be used as indicators of the health of a system.

In microalgal-dominated systems little data exists on the functional importance of individual species, so it is impossible to determine whether a particular species plays a functional role more important than suggested by its abundance or biomass. It has been remarked upon that most coastal ecosystems have a species diversity higher than that required for efficient trophic and biogeochemical functioning. If this is the case then there is considerable redundancy amongst species having a similar functional role within these system. In many rocky inshore environments kelps and other large brown seaweeds are key species since they provide the physical structure and microclimate that supports the biological diversity characteristic of these algal-dominated systems. Grazers are considered 'keystone' organisms if they increase species diversity by making available resources by selectively eliminating

competitively superior algae (see Underwood, 1992).

IN CONCLUSION

Aquatic systems remain underdescribed and undersampled and consequently data on biodiversity patterns and their underlying causes, maintenance and regulation are far from complete. Despite the inadequacy of our knowledge base concerning biodiversity patterns, it is still used to provide the essential scientific underpinning for decisions regarding the conservation and management of aquatic habitats. All too often biotic audits or inventories focus on the most abundant, or what are perceived to be 'keystone' or indicator organisms, rather than accurately identifying all component species. As a consequence important policy decisions concerning habitat conservation are all too frequently based upon what are unsound and critically inadequate data. In nearly all aquatic systems maintenance and functional integrity is dependent on algae, yet only exceptionally is serious consideration given to these key primary producers when carrying out conservation evaluations.

Various reasons exist for the neglect of microalgae in biodiversity audits and ecological investigations i.e., the small and declining numbers of phycologists trained in algal systematics, and the absence of modern systematic treatments along with associated interpretive literature. Clearly these problems are a result of the serious decline in taxonomic activity and the urgent need, therefore, for resources to be put into taxonomic research and the training of systematists. A shortage of systematists has created special difficulty for the 'Flora Committee' of the British Phycological Society who are responsible for the planning and organising a much needed modern freshwater algal flora for the British Isles. Activities related to such a Flora initiative should form a smaller part of a much wider and carefully targeted research agenda to address the key issues in conservation biology.

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Table 1. The known number and predicted world species totals of extant algal species.

Taxonomic Group	Known species	Estimated species	% known	Source of information on known numbers of species
KINGDOM PLANTAE[1]				
SUBKINGDOM VIRIDIPLANTAE (all green plants)				
Chlorophyta[2] (=Green Algae)				
Chlorophyceae	2,500	10,000-100,000	2.5-25	Melkonian 1989a
Prasinophyceae	120	500	24	Melkonian 1989c
Ulvophyceae	1,100	3,000	37	Floyd & O'Kelly 1989a
Charophyceae[3]	10,472-12,512	20,500[4]	51-61	Hoshaw et al.1989, Khan & Sarma 1984, Grant 1989, Silva 1982
SUBKINGDOM BILIPHYTA				
Rhodophyceae	2,500-6,000	5,500-20,000	12.5-100+	Woelkerling 1991
Glaucophycocysto-phyceae	13	50	26	Kies & Kremer 1989
KINGDOM CHROMISTA[5]				
Chromophyta *sensu lato*[6]				
Bacillariophyceae	10,000+	100,000[7]	10	Round & Crawford 1989
Bicosecophyceae[8]	45	1,000	4.5	Dyer 1989
Chrysophyceae[9]	1,000	2,400	42	Kristiansen 1989
Cryptophyceae[6]	200	1,200	17	Norris 1982
Eustigmatophyceae	12	1,000-10,000	0.1-1	Hibberd 1989a
Fucophyceae (Phaeophyceae)	900-1,500+	2,000	45-75	Clayton 1989, Wynne 1982
Haptophyceae (Prymnesiophyceae)	500	2,000	25	Green et al. 1989
Raphidophyceae	27[10]	100	27	Norris 1982
Synurophyceae	135-250	1,000	13.5-25	Andersen 1992
Tribophyceae (Xanthophyceae)	600	2,000	30	Hibberd 1989b
KINGDOM PROTOZOA				
Euglenophyceae	650-1,050	2,000	32.5-52.5	Walne & Kivic 1989
Dinophyceae[11]	2,000[12]	3,500-11,000	18-57	Taylor 1989
Chlorarchnidaceae[13]	3-4	20	15-20	Andersen 1992

[1] classification into kingdoms follows Cavalier-Smith (1981, 1983).

[2] classification principally follows Mattox & Stewart (1984); not included are the following orders of Green Algae of 'uncertain affinity': 25 spp. Microthamniales (see Melkonian, 1989d); 13 Pedinomonadales (see Melkonian, 1989b); 35 spp. Prasiolales (Floyd and O'Kelly, 1989b); 60 spp. Trentepohliales (see Floyd & O'Kelly, 1989c).

[3] includes Conjugatophyta: 10-12,000 known spp (Hoshaw et al., 1989); Charophyta: 440 spp (Khan & Sarma, 1985), 400 spp (Grant 1989); Coleochaetales, Klebsormidiales, Chlorokybales: 72 spp (Silva, 1982).

[4] estimate of total number of species includes Andersen's (1992) figures for Conjugatophyceae and Charophyceae.

[5] Labyrinthulids (slime nets), placed in the Chromista but usually regarded as protozoans or fungi; not considered here (38 spp., see Porter, 1989).

[6] considered remote from others groups placed in the Chromista; Cavalier-Smith (1989) created two subkingdoms, Chromophyta and Cryptista, and placed the Cryptophyceae into the latter.

[7] figure of 10 million appears in parenthesis in Andersen (1992), not accepted by us and is not used in any of our calculations.

[8] free-living heterotrophic flagellates, closely related to chrysomonads.

[9] includes Dictyochophyceae (silicoflagellates), considered separately by Andersen (1992) who recognises 10 known species and estimates total to be 15 species.

[10] 15 known genera given in Andersen (1992).

[11] allied to the Ciliata (see Dodge, 1989).

[12] About half of the ca. 4,000 of known species are fossil (Taylor, 1989).

[13] Chlorarchniophyceae, placed in the Kingdom Protozoa by Cavalier-Smith (1986, 1989).

Table 2. Comparison of the mean estimated numbers of known and predicted world species totals within the major series or lineages of algae. See Table 1 for detailed figures.

Taxonomic Grouping	Known species	Estimated known	Percentage
KINGDOM PLANTAE			
SUBKINGDOM VIRIDIPLANTAE			
Chlorophyta[1] (4 algal classes)	15,345	79,000	19
SUBKINGDOM BILIPHYTA (2 algal classes)	4,263	12,800	33
KINGDOM CHROMISTA			
Chromophyta *sensu lato* (10 algal classes)	13,776	117,200	12
KINGDOM PROTOZOA (3 algal classes)	2,853	9,270	31
TOTAL FOR ALGAE	**36,238**	**218,270**	**17**

[1] included are 133 species of green algae whose affinities are uncertain (see Table 1, note 10)

Table 3. Comparison of the numbers of known and estimated world species totals of algae with other selected groups of organism Earlier figures for algae cited by Hawksworth (1991, table 6) are given in parenthesis.

Taxonomic Grouping	Known species	Total unknown	Percentage known
Vascular plants[1]	220,000	270,000	81
Bryophytes[1]	17,000	25,000	68
Fungi[1]	69,000	1,500,000	5
Protoctista[2] (protozoa, excludes algae and fungal protoctists)	30,000	130,000	31
Eukaryotic Algae	36,238 (40,000)	218,270 (60,000)	17 (67)
Bacteria[1,2] (including Cyanobacteria)	3,000	30,000	10
Viruses[1,2] (including plasmids and phages)	5,000	130,000	4

[1] from Hawksworth, 1991, table 6.
[2] from Di Castri & Younes, 1990, table 1.

BRITISH PHYCOLOGICAL SOCIETY

Notice to Members, July 1994

Winter meeting, 3-6th January 1995, Portsmouth University

The 1995 winter Meeting will be held at Portsmouth University with Dr Clive Barwell kindly acting as local secretary. The meeting will start with a poster session, during the evening of Tuesday 3rd January. Following the pattern of the last two years, there will be an "applied" day on Wednesday 4th January with invited and contributing speakers on "**Valorisation and utilisation of marine algae**". The meeting will also include the Presidential Lecture by Dr Matt Dring (Helgoland, Germany) and two special sessions: "**Phosphorus responses of freshwater algae**" - co-ordinator: Dr B A Whitton, Department of Botany, University of Durham, Science Laboratories, South Road, Durham, DH1 3LE and "**Species concepts in algae**" - co-ordinators: Dr D G Mann, Royal Botanic Garden, Inverleith Row, Edinburgh, EH3 5LR and Dr C A Maggs, School of Biology & Biochemistry, Queens University, Belfast, N. Ireland, BT7 1NN. The Manton prize will again be awarded for the best student presentation. Individuals wishing to be considered should indicate this beside their abstract.

Papers or posters are invited on any algal topic, but those related to the special sessions will be particularly welcome. If you wish to submit a paper or poster, please send two copies of the name(s) and address(es) of the author(s), title and abstract (to fit the layout on the accompanying sheet) to Honorary Secretary **no later than October 10th 1994**. Tick whether paper or poster. The abstracts will be collated into a booklet for distribution at the meeting and abstracts of papers and posters given at the meeting will be published in the first part of the Phycologist (Issue 40). The total time allowed for each paper (including discussion) will be 20 mins (15 mins talk + 5 mins questions and discussion) and papers can only be accepted on the understanding that they may be timetabled on any day of the meeting. Posters must be on display for, and authors should be present on the evening of 3rd January.

Offers of papers/posters with abstracts must reach the Honorary Secretary at the address below by 10th October 1993. Late submissions will not be accepted.

Election for Council for 1995

A list of the present members of Council can be found inside the cover of any number of the Journal for 1994.

There are 4 vacancies for ordinary members of Council, one to serve for a single year (caused by the appointment of Dr A M Johnston to be Hon. Editor of the Newsletter, an ex-officio member of Council), 3 for the normal three-year term of office. Nominations for ordinary members are invited. They should reach the Hon. Sec. by 10th October 1994 and be accompanied by the name of one seconder and the written consent of the nominee to act if elected. Council does encourage members of the society to nominate members of Council.

This is your opportunity to choose your representatives.

STOP PRESS AUCTION

Following the success of previous Auctions, we will have another after the Society dinner at the Portsmouth meeting. There is no restriction on the type of article accepted, but those with loosely phycological associations or novelty value are encouraged. The more varied the selection the better. Anyone with items for sale is asked to **notify IN ADVANCE** Dr F G Hardy, 42 Harley Terrace, Gosforth, Newcastle upon Tyne, NE3 1UL, Tel: 091 222 6661, Fax: 091 222 7891.

IF YOU CANNOT FIND AN ITEM TO DONATE, COME WITH MONEY TO SPEND.

Scientific Meetings Fund

Some years ago, the British Phycological Society raised a trust fund - the Scientific Meetings Fund - to assist students to attend its meetings. Awards are normally made only when other support is unavailable. The maximum awards payable is the cost of the lowest possible return fare from the place of residence to the place of the meeting and the cost of subsistence in a Hall of Residence or other accommodation as arranged by the Society. Normally it is only possible to award part of this total cost. Although awards are not confined to students who are members of the Society, applications from student members will receive priority over applications from other students, and students who are presenting papers or posters at the meeting will also receive priority. Groups of students who travel together in order to reduce travel costs are encouraged to make joint applications.

Applications for awards to attend the Portsmouth meeting should be made to the Hon. Sec. before 9th December 1994 and should include:

1. Name and address;
2. Institution;
3. Status as student (degree for which registered, year of study);
4. Subject of study;
5. Details of other support obtained, or applied for;
6. Brief supporting statement by supervisor/tutor/head of department;
7. Estimated cost of fares and subsistence.

All applications will be considered by Council during the course of the meeting, and any awards will be available immediately.

Manton Prize

A prize will be awarded for the best student paper presented during the Winter Meeting. Any students wishing to enter should indicate this beside their abstract. This will allow papers to be grouped in the same session.

N.B. **THE ABSOLUTE DEADLINE FOR PAPERS + ABSTRACTS IS 10TH OCTOBER 1994**

Dr E J Cox (Hon. Secretary), British Phycological Society, Department of Botany, The Natural History Museum, Cromwell Road, London SW7 5BD, UK.

SUBSCRIPTIONS

Members are reminded that subscriptions for 1995 are due on or before 15th January. The rates will be:

Ordinary Members (receiving Journal)	£25.00
Student & Retired Members (receiving Journal)	£20.00
Ordinary Members (not receiving Journal)	£10.00
Student & Retired Members (not receiving Journal)	£ 5.00

Subscriptions may be paid in the following ways:

1. Cheque/money order made payable to **The British Phycological Society**. If paid in dollars membership is US$ equivalent plus 2$ to cover bank charges.
   Send them to: The Hon. Membership Secretary (Mr S J M Droop), British Phycological Society, c/o The Royal Botanic Garden, Inverleith Row, Edinburgh, EH3 5LR, UK.

2. If you have a British bank account you may pay be Banker's Order mandate.
   A form for this was sent to you earlier and should be returned to your own bank.

3. Credit card. A form for this was sent to you earlier. Please note the extra £1 which covers charges for processing.
   Return form to: The Hon. Membership Secretary (Mr S J M Droop), British Phycological Society, c/o The Royal Botanic Garden, Inverleith Row, Edinburgh, EH3 5LR, UK.

Algal Research at the University of Portsmouth.

There are active groups working on different aspects of marine algal research in three of the departments in the Science Faculty of the University of Portsmouth. In the School of Pharmacy and Biomedical Science the emphasis is on compounds and products with potential economic value. Professor David Rogers has been working for many years on the isolation, characterization and utilization of lectins from marine algae, in particular from the genera *Codium*, *Ptilota, Plumaria, Solieria* and *Griffithsia*. Professor Rogers is also collaborating with groups in other universities specialising in lectin research; these include those of Professor Hori, University of Hiroshima, Japan; Alex Sampaio, Federal University of Ceara, Forteleza, Brazil; and Yu Qi, Institute of Sports Medicine, Beijing, China.

Professor Gerry Blunden and Yue Wu, School of Pharmacy and Biomedical Sciences, and Dr Teifryn Jenkins, School of Biological Sciences are working on the uses and mode of action of brown seaweed extracts used in agriculture and horticulture. Recent important advances have been the demonstration of the value of betaines in the extracts. These compounds, in very low concentrations, have been shown to have significant effects on increasing leaf chlorophyll levels and in reducing the incidence of pathogen attack on plants. This work is being done in collaboration with Dr E. Tyihak, Plant Protection Institute of the Hungarian Academy of Sciences, and Dr S. Hankins of Maxicrop International Ltd, Corby, Northants. Professor Blunden, Dr Ming-he Yang, Dr David Thurston and Janet Currie are also investigating marine algae as a source of compounds with potential medicinal value.

Dr Clive Barwell and Dr Eamon Cunningham are evaluating marine algal species as

sources of phycobiliproteins and other pigments; this is being done in collaboration with Silvana Saker Sampaio of the Federal University Ceara, Brazil. These compounds are being investigated both for biomedical applications and for incorporation into human foods. Dr Barwell is also involved in a programme to determine the biochemical composition of edible seaweeds and algal food products. This is a collaborative programme with CEVA, Pleubian, France.

In the School of Biological Sciences Dr Yvonne Chamberlain continues with her studies of the coralline red algae. Along with Dr Linda Irvine she has recently published Seaweeds of the British Isles, Vol 1. Rhodophyta Part 2B Corallinales, Hildenbrandiales. Until recently Margaret Steentoft has been working in the School on *Gracilaria* and *Gracilariopsis* species, but unfortunately she has now returned to Denmark. Dr Robert Fletcher is continuing with the production of Volume 3, part 2 on the Phaeophyta of the British Isles. Other research interests of his included marine fouling algae, in particular aspects of spore settlement and attachment. Bob is also making a study of marine algal species of eutrophicated waters. Dr Bill Farnham continues with his work on the marine flora of the Solent region, with particular emphasis on the Isle of Wight.

In the Department of Chemistry, Dr Brian Plunkett is working on marine algae as an organic feedstock. This project is a collaborative one involving several European partners and is part of the COST 48 Action Programme.

Recently the multidisciplinary Institute of Coastal and Marine Studies (ICAMS) has been set up at the University of Portsmouth under the chairmanship of Dr Clive Barwell. The purpose of this institute is to act as an umbrella organisation for the many coastal and marine research interests within the University, including all the groups involved with the various aspects of marine algae.

CONSERVATION MATTERS

BPS Conservation Committee

The 1992 Earth Summit in Rio de Janeiro and the signing of the Biodiversity Convention have ensured that biodiversity and conservation are now high on the political agenda. In view of various government initiatives following in the wake of the Earth Summit and new EC Directives on the environment, I decided to solicit the views of members of the BPS Conservation Committee as to its future role. There was general agreement that its membership should be broadened with the result that Juliet Brodie, Jacqueline O'Mahony and Gavin Hardy have now joined the committee. At the first meeting of the re-organised committee held in January 1994 at Liverpool University decisions were made, as to its structure, aims and objectives, and future role. A report of this meeting was prepared by the secretary (Juliet Brodie) and appeared in the March edition of The Phycologist.

Past and Present Activities of the Conservation Committee

Over the course of last year we were asked to respond to various consultative papers and documents. The Head of the Species Conservation Branch of JNCC, Margaret Palmer asked the BPS to comment on the draft of a document entitled 'Plant Conservation Strategy' that dealt with both higher plants and lower plants. A three page response was prepared by the committee on behalf of the Society. In December 1992 we expressed considerable concern

to the Project Development Group for SERCON (System for Evaluating Rivers for Conservation) who were proposing not to consider microalgae as attributes to be used in their system. Despite our reservations, algae have not been incorporated into SERCON alongside other groups. The use of algae in conservation evaluation is only recommended where information is already available, otherwise they are considered under 'Additional Characteristics of Importance'. We were also asked to respond to a DoE consultation paper on the implementation of the EC Directive on the 'Conservation of Natural Habitats and of Wild Fauna and Flora', known as the 'Habitats Directive' (see below). Only six weeks was allowed for the process of consultation for the Directive that the government has to implement by June 1994. There was insufficient time for a response but Plantlife produced a very detailed one on behalf of its affiliated societies of which BPS is a member of its Conservation Forum.

We have been requested by Dr Clare Eno of the Marine Conservation Branch of the Joint Nature Conservation Committee (JNCC) to provide information on marine species introduced into British and Irish waters. The information they are gathering on non-native marine species is being used to develop an overview of the subject and to evaluate actual and potential effects of introduced species on indigenous species and communities. The JNCC has also asked for information on sites of high conservation value to be considered for protection under the EC Habitats Directive. It was reported in the May 1993 issue of MARINE SCENE that the JNCC had prepared a map identifying stretches of coastal water under consideration for protection under the Directive. It was originally planned to discuss the preliminary sites with other specialists but discussions have become restricted to within the British statutory nature conservation bodies. The government has to produce a list of designated sites by mid-1995.

We sent the document 'Conservation Priorities of the British Phycological Society' to Plantlife in response to a request to their affiliated societies to assist in drafting a prospectus on a plant conservation strategy. Further algal input into the 'Prospectus' was discussed with those compiling it (principally Dr Hugh Synge) at a meeting held on 12 January at The Natural History Museum. It is proposed to publish the 'Prospectus' during 1994.

Biodiversity and Conservation

The government's response to the Earth Summit was to develop the 'Darwin Initiative' and the 'Biodiversity Action Plan'. A workshop organised by the DoE and JNCC in May last year considered the Action Plan in some detail. A month ahead of the 25th of January launch of 'Biodiversity: UK National Action Plan' there was published 'Biodiversity Challenge: an Agenda for Conservation in the UK', compiled by six voluntary conservation bodies. This NGO document gave realistic objectives and precise targets for conservation together with suggestions for policies and actions considered essential for these to be met.

The following is extracted from items in Scottish Environment News (SCENES):

Habitats Directive

'The main obligation of the Directive is that the government should designate sites, on land and sea, to form part of an EC "Natura 2000" network of protected areas in order to ensure the restoration or maintenance of natural habitats and species of community interest as a favourable conservation status'. These sites will comprise Special Areas of Conservation (SACs) under the Habitats Directive and Special Protection Areas (SPAs) under the 1979 EC Directive on the conservation of wild birds. The SACs will be selected from a range of

priority habitat types listed in Annex I of the Directive as being of special importance in the EC. These include active raised bogs, active blanket bogs, limestone pavement, and coastal lagoons. SACs must also be established to protect priority species listed in Annex II of the directive... The government will be required to protect these SACs and SPAs from deterioration or disturbance which will affect the nature conservation of the site, and to take steps to conserve the interest of the site ... The measures in the Directive extend beyond these protected sites.... "to encourage the management of features in the landscape which are of major importance for wild fauna and flora. Such features in the landscape which are of virtue of their linear and continuous structure (such as rivers with their banks...) are essential for the migration, dispersal and genetic exchange of wild speices". There are also specific measurements to protect priority species, including a requirement to manage the exploitation of reindeer lichen, bog mosses, clubmosses and maerl seaweed... Despite strong arguments from a number of conservation bodies ... the government proposed no new legislation to implement the Directive. It argues that existing legislation already provides a sound basis for the implementation of the directive. It argues that existing legislation already provides for the implementation of the directive. Indeed, the government suggests that, in practice, all SACs and SPAs will already have been notified as Sites of Special Scientific Interest (SSSIs) and will therefore be protected under the powers of the Wildlife and Countryside Act.

The full article appears under 'Conservation' and 'Marine' in the October 1993 issue of SCENES and the mention is made in the November issue of SCENES of the Marine Conservation Society's concern over government response to the Directive.

David M. John, Chairman of the Conservation Committee of the British Phycological Society, the Natural History Museum, Cromwell Road, London SW7 5BD

Book Review:

An illustrated history of the life history of algae (Vol. 3)

ed. **Terumitsu Hor**

Uchida Rokakuho Publishing Co. Ltd., Tokyo xvii + 313 + 62 pp (In Japanese; UK price not available).

This is the third volume in series designed to give the reader access to the currently available information on the life histories of algae. The first volume is concerned with the green algae, volume two with the Phaeophyceae and Rhodophyceae, whilst this third volume summarises the information on the unicellular and flagellated algae. In practice this means members of the Dinophyceae, the Euglenophyceae, Cryptophyceae and the chromophyte groups, diatom, haptophytes, chrysophytes etc., since unicellular members of the green and red algae are included in volumes one and two.

The taxonomy used is relatively conservative, with class as the highest rank used, followed by order and then the representative species. Each species has a double page entry with one page of illustrations facing a page of text, each entry having been contributed by a specialist in the field. The text for each species is divided into sections giving references, an explanation of the life history, distribution, sometimes with an inset map showing the distribution around Japan, and an explanation of the figures. The illustrations consist for the most part of line drawings, sometimes from published work, but with many originals, and occasionally with an included half-tone micrograph.

The drawings and micrographs are all of a very high quality and although the labelling is in Japanese, it is generally easy to understand the points that are being illustrated since the explanation of the figures is given in English on the opposite page. Most of the literature references are also accessible, being in English, German and French, but the section of text explaining the life-history and that giving the distribution and other notes are in Japanese.

There is a good taxonomic index indicating both illustrations and textual references. In addition, a very useful appendix gives an index to the catalogue number of the strains held in the Culture Collection of the National Institute for Environmental Studies, the culture media used for their maintenance, and the recipe of the media themselves. At the beginning of the book is a Japanese/English glossary of selected terms.

Clearly this series is aimed at the Japanese market. Nevertheless, there is a wealth of information induced and an indication of the vast amount of research that is still needed to understand the life-histories of the unicellular algae, may of which are still known only from one form, usually as unicellular flagellates. The editor must be congratulated on having coordinated so many contributors with such success!

Seaweeds of the Yorkshire Coast

The marine macro-algae of the Scarborough district were studied by Massee in the late nineteenth century (Massee, 1885) and again by Perkins and co-workers in the mid-twentieth century (Perkins, 1953). The marine algae of the chalk cliffs at Flamborough were studied more-recently by George and co-workers (George et al., 1988; Tittley, 1988). The literature relating to the seaweeds of the Yorkshire coast has been reviewed by Hardy and Scott (1995).

The British Phycological Society held a seaweed identification course at University College Scarborough in July 1994, when material was collected and examined from three locations in North Yorkshire and Humberside (see Table 1).

Material was collected from Black Rocks, Scarborough South Bay, from the shore immediately in front of the Holbeck Hotel landslip (summer 1993). The shallow sloped wave cut platform is divided into two distinct zones: the upper and upper-middle shore which was smothered by the landslip and cleared of all algae; and the lower shore which is presumed to be close to its pre-landslip state.

At Flamborough Head there is a wide bay dominated by a considerable biomass of seaweeds, especially *Fucus* species. This is enclosed by chalk cliffs (on which grows a population of *Fucus spiralis* var. *nanus*).

Filey Brigg is a line of rocky ledges extending about half a mile seaweed from Carr Nase and bounding Filey Bay on its north side. The top reef is skirted on its south side by masses of large weathered boulders, and on its north side by a lower outer reef which is always submerged at its eastern end. The Brigg is one of the most famous collecting sites on the Yorkshire coast (Perkins, 1953).

The algae identified during the course are listed in Table 1. The nomenclature used in the list is based on that used by Parke and Dixon (1976) with updated amendments taken from those parts of Seaweeds of the British Isles which have been published to date (Burrows, 1991; Dixon & Irvine, 1977; Fletcher, 1987; Irvine, 1983; Irvine & Chamberlain, 1994; Maggs & Hommersand, 1983). Further, *Mastocarpus stellatus* (Stackh. in With.) Guiry is

used *in lieu* of *Gigartina stellata* (the name used in Dixon and Irvine, 1977).

Table 1. List of algae collected Yorkshire coast, July 1994.

Site 1: Black Rocks, Scarborough South Bay, material collected 22nd July, 1994.
Site 2: Flamborough Head, visited 23rd July, 1994.
Site 3: Filey Brigg, visited 24th July, 1994.

	Site 1	Site 2	Site 3
RHODOPHYTA			
Ahnfeltia plicata		*	
Audouinella daviesii		*	
Audouinella floridula		*	*
Brongniartella byssoides			*
Aglaothamnion hookerii		*	*
Catenella caespitosa			*
Ceramium deslongchampii	*	*	*
Ceramium gaditanum	*		
Ceramium nodulosum	*	*	*
Ceramium shuttleworthianum		*	*
Ceramium strictum			*
Chondrus crispus	*	*	*
Corallina officinalis	*	*	*
Cryptopleura ramosa		*	
Cystoclonium purpureum	*	*	*
Delesseria sanguinea		*	*
Dilsea carnosa		*	*
Dumontia contorta	*		*
Furcellaria lumbricalis		*	
Gelidium pusillum			*
Hildenbrandia rubra	*		*
Laurencia hybrida	*	*	
Laurencia osmunda		*	
Laurencia pinnatifida	*	*	*
Lithophyllum incrustans		*	*
Lithothamnion glaciale	*		
Lomentaria articulata	*	*	*
Lomentaria clavellosum			*
Mastocarpus stellatus	*	*	*
Membranoptera alata	*	*	*
Nitophyllum punctatum		*	
Odonthalia dentata		*	
Palmaria palmata	*	*	*
Phycodrys rubens		*	*
Phyllophora pseudoceranoides		*	
Phymatolithon lamii		*	*
Phymatolithon lenormandii	*		*
Phymatolithon purpureum		*	*
Plocamium cartilagineum	*	*	*
Plumaria plumosa		*	
Polyides rotundus		*	*
Polysiphonia brodiaei		*	*
Polysiphonia fucoides			*
Polysiphonia lanosa			*
Polysiphonia nigra		*	
Polysiphonia stricta			*
Polysiphonia sp (harveyi/stricta)			*
Porphyra leucosticta	*	*	*

	Site 1	Site 2	Site 3
Porphyra purpurea	*		
Porphyra umbilicalis		*	*
Ptilota gunneri		*	
Rhodomela confervoides		*	*
Titanoderma pustulatum		*	
PHAEOPHYTA			
Alaria esculenta			*
Ascophyllum nodosum			*
Chordaria flagelliformis	*		*
Cladostephus spongiosus		*	*
Colpomenia peregrina		*	*
Desmarestia aculeata			*
Dictyosiphon sp		*	*
Dictyota dichotoma			*
Ectocarpus siliculosus		*	
Elachista fucicola	*	*	*
Fucus serratus	*	*	*
Fucus spiralis			*
Fucus spiralis var. nanus		*	*
Fucus vesiculosus	*	*	*
Giffordia granulosa		*	
Halidrys siliquosa	*	*	*
Himanthalia elongata		*	*
Laminaria digitata	*	*	*
Laminaria hyperborea		*	*
Laminaria saccharina		*	*
Leathesia difformis			*
Pelvetia canaliculata			*
Pilayella littoralis			*
Scytosiphon lomentaria		*	
Spongonema tomentosum	*	*	*
CHLOROPHYTA			
Blidingia minima	*		*
Bryopsis plumosa	*		
Chaetomorpha melagonium		*	*
Cladophora hutchinsiae			*
Cladophora laetevirens	*		
Cladophora rupestris		*	*
Enteromorpha intestinalis	*		*
Rhizoclonium tortuosum		*	*
Spongomorpha aeruginosa	*		*
Ulva lactuca	*	*	*
Ulva rigida	*		*
Ulothrix flacca	*		

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G.W. Scott, The Centre for European Coastal Studies, University College Scarborough, Filey Road, Scarborough, N. Yorks., YO11 3AZ.

BPS Field Meeting, Scarborough, North Yorkshire, 1994.

In July 1994, over the weekend of the 23rd - 24th, the British Phycological Society held its third annual field meeting in Scarborough, North Yorkshire, an area of great phycological interest. Accommodation and laboratory facilities were provided by University College, Scarborough. The course was attended by some thirty phycologists from various institutions in Britain and beyond, with participants including established professionals, students and interested amateurs.

The assembled phycologists appeared on Friday evening and immediately took up position within the laboratory. A taste of the flora we could expect to encounter during the weekend was provided by material which had been collected from Black Rocks, South Bay Scarborough, the site of the 1993 Holbeck Hotel landslip. The identification session ceased only when the phycologists found themselves detached from their holdfasts and washed ashore inside 'The Hole in the Wall', a public house recommended by both the 'Good Pub Guide' and thirty thirsty phycologists.

The Flamborough Head area, a wide bay enclosed by chalk cliffs, was visited at low-tide, at midday on the Saturday. The abundant algal biomass was apparent from the cliff top, and its luxuriance evident when attempting to wade through the mid shore region, dominated by *Fucus serratus* and *F. vesiculosus*. Much general interest was engendered as members of the party performed gymnastic displays while in pursuit of interesting specimens. The lower shore was dominated by *Laminaria digitata, L. hyperborea* and *L. saccharina*. The water clarity was good, and in the strong sunshine the iridescent tips of *Chondrus crispus* provided welcome colour. Once loaded with the days 'catch' the steep climb back to the cliff top was

made, and after enjoying a well deserved ice cream the group reassembled back at the laboratory. The following session was spent sieving through collecting bags, observing specimens under microscopes, working through field keys and the various volumes of seaweeds of the British Isles, with the ultimate aim of adding further names to the ever expanding species list. During this session, students and amateurs got to grips with the general flora whilst the professionals supplied advise and expert help.

Our second expedition, on Sunday, was to Filey Brigg, a famous site on the Yorkshire coast. This exposed shore was to be an area that I would not easily forget. Huge samples of *Mastocarpus stellatus* were found in the mid shore region. The rock pool floors were matted with *Corallina officinalis* and contained four species of *Ceramium*. At the tip of the headland an increase in numbers of the Chlorophyta was probably correlated with the presence of a sewage outflow pipe. This was the probable source of the infection that developed in a small wound on my heal. After feeling unwell on my return home I was diagnosed with infective cellulitis and was rushed into hospital, where I stayed for three days on intravenous drugs, before being released with a further seven day course of oral antibiotics. This incident has certainly increased my awareness of the hazards involved when working on potentially polluted shores.

As a postgraduate student I would recommend the BPS seaweed identification course. I think that all participants benefited greatly, with the possible additional bonus of three relaxing days in a hospital bed. The course was run in a leisurely and friendly manner, and adequate time was available for individuals to exchange ideas and information. It provided a good chance to observe and get to grips with those species that you have, to date, not had the time or opportunity to examine. Some 91 species were identified during the weekend form the three collection sites. I look forward to the Isle of Man field meeting next year, and hopefully to a possible future field meeting in Spain.

Jeremy Plumb.
Bath College of Higher Education.

NEWS AND GENERAL INFORMATION.

Denis Greenwood:
Denis (A.D.) Greenwood died suddenly and unexpectedly on 5 April 1994 at the age of 78. He was a well known member of the British Phycological Society and regularly attended annual meetings including the 1984 meeting in Liverpool. Most of phycological research was carried out during his time at Leeds University in collaboration with the Late Professor Irene Manton and subsequently at Imperial College London. A fuller appreciation will be published in the next edition of the Phycologist.

Barry Leadbeater

A New Knight in the land.
In the 1994 Queen's Birthday Honours Professor Bill Stewart was awarded a Knighthood for services to science. I would like to extend to Bill the Societies heartiest congratulations on his award.

Andrew Johnston

A Phycological Union Between the U.K. and the U.S.

Eileen J. Cox and L. Elliot Shubert married on 4 June 1994, escaped to Ireland for a honeymoon, and are now living in London. Eileen is continuing her work at The Natural History Museum, which is also Elliot's professional base at the moment. Elliot is interested in developing collaborative research projects with colleagues in the U.K. and Europe. His research interests are the ecology of soil algae, and the ecophysiology of algae exposed to heavy metals. He is also pursuing part-time teaching and consulting in the vicinity of London. Elliot would like to hear from colleagues, who may have ideas or leads for employment.

Eileen Cox

David Thomas.

It seems everyone is going east. Word has reached me that David Thomas has moved from the Alfred Wegener Institute to the University of Oldenburg at the new Institute for the Chemistry and Biology of the Sea (ICBM). David is working on the KUSTOS project looking at phytoplankton/bacterioplankton of the German Bight. His new address is listed in the Directory of members in this issue.

E.mail discussions lists.

You will have been living on Jupiter if you haven't heard of the Super Highway or the Internet. Well for those of you who use computers and would like to hook up to some interesting discussion then here are two lists for you.

The first was set up by Mike Guiry (University College, Galway, Ireland). It is a public list called ALGAE- L which replaced the e-mail newsletter Mike ran for a short time. It has about 200 members at the moment. It is not moderated (censored by Mike) so a degree of self restraint is requested.

Here is a modified version of the simplified instructions for ALGAE-L. You might like to distribute this to interested persons. The list is simply for the distribution of messages of common interest to those who subscribe. Please join as the more persons there are, the more useful will be the list. There is absolutely no charge or obligation and, if you wish, you can sign off the list at a later stage (details are sent to you when you sign on). If you have no experience of such lists, let me explain: a public list is a list of addresses to which anybody can send a message which is then distributed to every address on that list. Usually, it is some news (jobs, book details, etc.) but it can be requests for information, specimens, etc.

1. SUBSCRIBING

Send a mail message to LISTSERV@IRLEARN.UCD.IE [please note that it is NOT "LISTSERVER" but "LISTSERV"] with no subject heading and the single line: SUB ALGAE-L followed, on the same line by your first name and your second name [please note that it is NOT "ALGAL-L"]. Put a <return> at the end of the line, particularly if you use an automatic mail "signature". Please note that the server may be a bit slow at times because of heavy traffic.

2. SENDING A MESSAGE

To contact all the people currently subscribed to the list, just send your mail message to ALGAE-L@IRLEARN.UCD.IE. This is called "sending mail to the list", because you send mail to a single address and LISTSERV makes copies for all the people who have subscribed. Be sure to include your e-mail address at the end of any such message. Try not to send frivolous messages as people will rapidly signoff the list and its effect will be

diminished.
Do please bear in mind that a lively discussion is something that lists should encourage, but do remember that even the mildest personal comments can be very hurtful when made in public. So, please THINK before hitting the REPLY button as you will be reaching >200 people.

Please contact Mike Guiry [mike.guiry@ucg.ie] directly if you have any difficulties.

The second list is a little older and it deals specifically with Diatoms. If you wish to join this list then send the message SUB DIATOMS-L name name to LISTSERV@IUBVM.UCS.INDIANA.EDU

When subscribing to a discussion list it is a good idea to save all the technical information they send you about sending mail, signing off the list, stopping mail for short periods (holidays) etc.

A further development of particular interest to those with access to TCP/IP is that several WWW (World-Wide Web) servers are being planned that will be of considerable interest to phycologists. These will be announced on the above lists and in a future issue of The Phycologist.

Andrew Johnston

MacIntosh image analysis software for coccoliths.

As part of an EC funded project on the ecology and biogeochemical impact of the coccolithophore *Emiliania huxleyi* I have been developing an image analysis application, to automate biometric work on *E. huxleyi* coccoliths. It consists of a set of macros for the program NIH-Image. This is a very respectable Image Analysis program produced as freeware by the National Institutes of Health in the USA for scientific research work. It is only available for Apple MacIntosh computers.

Broadly the macros I have written do two things.
1. Create composite "mosaic" images of 30 specimens (coccoliths are rather small objects). This make archiving and biometrics easier and allows the operator to identify the specimens to measure.

2. Go through these mosaic images automatically measuring several parameters on each specimen and displaying the results. Additional macros enable errors to be corrected, etc. Together with the macro files are specimen images and text files explaining the macros and their use. Although these macros are customised for coccoliths aspects of the approach could be of interest to work on other phytoplankton groups.

The program NIH-Image with full documentation is available via anonymous FTP from zippy.nimh.nih.gov. The macros I have written are also available on this site (contributions directory, CoccolithBiometics). If you do not have easy access to the Internet then I will happily send a copy of the program, macros, specimen images, if you send me a blank formatted MacIntosh disk, together with a stamped addressed envelope to return it to you in.

Jeremy R. Young
The Natural History Museum
LONDON,

BPS WINTER MEETING, 1995.
University of Portsmouth, 4-6th January 1995. See pages 18, 20

***Emiliania huxleyi* AND THE OCEANIC CARBON CYCLE.**
An International Conference presenting results of the multidisciplinary EC (MAST II) funded programme "Coccolithophorid Dynamics: The European *Emiliania huxleyi* Programme (EHUX)".

Anouncement/Invitation

This conference will present results from "Coccolithophorid Dynamics: The European *Emiliania huxleyi* Programme (EHUX)". This is a multi-disciplinary programme funded by the Marine Science and Technology initiative of the European Commissions. Its objective is to deepen our understanding of the marine component of the global carbon cycle by intensive study of a single core-component of that cycle - the coccolithophorid alga *Emiliania huxleyi*. The reasons for this choice were obvious: it is one of the most abundant planktonic species, is readily cultured, has an excellent fossil record, and plays important parts in the biogeochemical cycles of both sulphur and carbon. By concentrating on a single species we are able to investigate the interactions of a much wider range of processes than is normal in global cycle studies, and to investigate the actual non-linear responses of real organisms rather than treating the entire biota as a single biogeochemical pump. Projects within the research programme range from satellite monitoring of gigantic blooms to laboratory-based studies of intracellular processes. Disciplines involved include cell biology, molecular genetics, morphological taxonomy, phytoplankton ecology, marine biology, biochemistry, organic geochemistry. The studies on particular aspects of the organism and its interactions with the environment are complemented by a series of projects producing synthetic computer models based on them. This modelling is a key goal of the programme, exploring the inter-relationships of the diverse phenomena under study and bringing the experimental findings into a coherent picture.

The work has been in progress for about 5 years, as the Global *Emiliania* Modelling initiative (GEM), with EC funding since Jan. 1993, and has been co-ordinated via a series of internal workshops held in Blagnac, France. This conference will provide an opportunity to present together the results of the numerous component projects, plus separately funded geological and biogeographical studies on *Emiliania huxleyi*. It will be open to any interested scientists and strictly relevant talks from outside the main research group will be welcome.

Relevance to Phycologists: We hope many phycologists working on groups other than coccolithophores would find the multi-disciplinary approach stimulating and we are pleased to invite you to attend.

Date: Weds 5th-Sat 8th APRIL 1995 (Scientific sessions Thurs 6th & Friday 7th).

Venue: The Natural History Museum, Cromwell Road, London, UK. Accommodation will be available in Imperial College halls of residence. Cost ca. 25/day B&B.

Organisers Convenor: Jeremy R. Young (Palaeontology Dept., The Natural History Museum, London). Organising Committee: Roger Harris (Plymouth Marine Laboratory, UK), Peter

Westbroek (Dept.of Chemistry, Leiden University, The Netherlands), Ber
of Fisheries and Marine Biology, University of Bergen, Norway).

Registration: Full registration about £ 50, to include coffee, abstract v
reduced day rates and student rates.

TO BE INCLUDED IN THE CIRCULATION LIST PLEASE CONTAC

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CHRYS 95

The Fourth International Chrysophyte Symposium will take pl
(Hosterkob, north of Copenhagen) 22-27 May 1995, followed by an o
excursion to Sweden (Aneboda). The programme will include invited lect
papers and posters. Manuscripts will be published in the Proceedings of
Organizers: Gertrud Cronberg (Lund, Sweden) and Jorgen Kristianse
Denmark).

For further information contact Jorgen Kristiansen, Botanical In
Phycology, Oster Farimagsgade 2 D, 1353 Copenhagen K, Denmark. Tel
Fax: 45 3532 2321 Email: sporol@vm.uni-c.dk.

First International Congress on Toxic Cyanobacteria (Blue-green Algae

Since 1986 Nordic Symposia on toxin producing algae have been held eve
Due to the increased interest from other countries in these meetings and the
topics relating to toxic cyanobacteria not being covered by other internation
organizing committee has decided to make the 1995 meeting the 1st Interna
on Toxic Cyanobacteria (Blue-green Algae).

The Congress will be held on the Danish island of Bornholm in the
August 1995. It will be held in English. We plan to publish the procee
Congress.

Scientific communications to be presented orally or as posters are
aspect of toxic cyanobacteria. Subjects such as ecology, physiology, factors
production, management, health hazards, and general aspects of toxic cya
serve as a tentative guideline to the scientific sessions intended.

To receive the first circular which included preliminary registration form, pl

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Introduction to the Membership List

Welcome to the new BPS membership list -- you may agree that it's somewhat overdue!

First of all, a big THANK YOU to all of you who returned our questionnaire or who found some other way of alerting us to changes or additions to any of your details. The list is not completely right, but we've done our best.

We have tried to treat the details we've included more or less consistently, especially telephone and fax numbers: we've adopted a standard that has meant including the country code in each one. In some cases this has necessitated a bit of detective work, and there are bound to be a few mistakes (e.g. missing or redundant zeros). We've also tried to check e-mail addresses. Please let me know about any mistakes or missing information -- the list can't improve for the future unless you do.

We've decided, at least for this list, only to include details of name, address, telephone, fax and e-mail. Future lists may also include an index to members by research interest, and/or a geographical index. Please let me know if you feel strongly, or if you have any other ideas as to how the list could be improved.

It should be noted that as of 16th April 1995 the National Codes in the UK will change. For most areas this will mean adding a 1 to the number. Dundee is 0382 and will become 01382. There are five exceptions to this where the whole number will change, **Bristol** goes from 0272 to 0117-9, **Leeds** from 0532 to 0113-2, **Leicester** from 0533 to 0116-2, **Nottingham** from 0602 to 0115-9 and **Sheffield** from 0742 to 0114-2. If there are any other changes these will be noted in future issues.

S.J.M. Droop
Hon. Membership Secretary

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