



The Phycologist

The Newsletter of

The British Phycological Society

THE PHYCOLOGIST

NUMBER 37 - MARCH 1994

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Welcome to the 37th edition of *The Phycologist* and my first as editor. Firstly I would like to thank Robert Edyvean and Dave Williams for all their help in getting this issue together and guiding me in the ways of editorship. I don't expect there will be many changes from the previous house style. I should apologize for the lateness of this issue which was due to some doubt as to whether I would be able to continue as editor. I have decided to give it a go and in future will strive to meet my deadlines! I would like to welcome Dr Judith Talyor to the production team.

For those who don't know me, or of me, and as there are over 650 members of the society there must be quite a few of you, I should introduce myself. My name is Andrew Johnston and I am an Advanced NERC Fellow working in the Department of Biological Sciences at the University of Dundee. My research is concerned with investigating the influence of CO₂ concentration on the photosynthetic characteristics of macro- and microalgae with particular emphasis on the ¹³C/¹²C ratio using stable isotope analysis.

This issue is traditionally primarily concerned with reporting in some detail on the Winter meeting of the society. There is a full listing of abstracts of papers and posters presented, again numbers are up on previous years. I should apologize for the "Dundee mafia" feel to the reports but I thought I would like to do the full report, Vice-Presidents traditionally write a report and this year that means John Raven. I canvassed opinion from some post-graduate students for a suitable student reporter and the name that kept on coming up was Beki Korb, who is a student of John Raven and myself! One of the major topics at the winter meeting was Algae and Conservation. I had hoped to have a full report from Dave John for this issue but unfortunately it will not be ready and will appear in the next issue. This is an aspect of the society's work that I feel will become increasingly important and I hope to have regular features in future issues.

Stephen Droop, the Hon. Membership Secretary, has a short piece in which he summarises details of the society's membership, I was surprised to see how many members are non-resident in the UK. Stephen has been updating the membership records and we hope to have a complete listing in the next issue. As is traditional there is a short report on the AGM from the Hon. Secretary, and reports from the Hon. Treasurer, the European Journal of Phycology Management Committee (EJPMC), the BPS Conservation Committee and the Irene Manton prize from Len Evans.

At the last AGM the membership agreed to some changes to the constitution of the Society so I thought that members would be interested to see the constitution in full and it is published in this volume. As there have been a number of changes to the BPS Council I have included a listing to the current line up with addresses, telephone and Fax numbers and in some cases E-Mail addresses.

Barbara Ward has been kind enough to relate her experiences on the 1993 BPS Field meeting which was held on the Isle of Wight. It sounds like a great opportunity to relearn a lot of macroalgal taxonomy with experts in the field and I think I may well go to the 1994 course which will be held in Scarborough.

I don't know if you, like me, have found the recent trend of flyers falling out magazines very irritating but I have decided to try something different in this issue. You will see that the order form for the T-shirts / sweat shirts and summer field meeting are in un-numbered centre pages so you can pull them out without chopping into your newsletter. The

T-shirts and sweat shirts did remarkably well at the Winter meeting and you can see the design on page 10. Every British Phycologist should have one.

Andrew Johnston.

BPS COUNCIL 1994.

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THE BRITISH PHYCOLOGICAL SOCIETY
CONSTITUTION AND RULES.

GENERAL

1. The name of the Society shall be "The British Phycological Society".
2. The aims of the Society shall be to advance education by the encouragement and pursuit of all aspects of the study of algae and to publish the results of this research in a journal, and also in other publications which shall from time to time appear desirable, provided that all publications of the Society shall be available to the general public.

All funds acquired by the Society shall be devoted to the aims detailed in paragraph 2 above or to such associated charitable projects as may from time to time further these aims.

MEMBERSHIP

3. Membership of the Society shall be open to anyone interested in any aspect of the study of algae. Application should be made to the Hon. Membership Secretary, who will supply a form to be completed, signed and returned by the applicant. Applications shall be considered by the Council. A copy of the Constitution and Rules of the Society shall be made available on request from the Hon. Membership Secretary. Applications for Corporate Membership may be considered by Council.
4. Fully paid-up members shall have the following privileges:-

- a. To receive all notices pertaining to the activities of the Society and to attend all Meetings and Excursions.
 - b. To receive all literature issued by the Society, free or at a reduced rate as the Council may from time to time determine.
 - c. To vote in the election of the members of the Council, and to vote in the conduct of the affairs of the Society at any meetings of the Society.
 - d. To be eligible for service on the Council and its committees, or as Officers.
 - e. To introduce visitors at any meeting of the Society (with the exception of the Annual General Meeting), unless the Council by resolution suspends this privilege for any particular reason.
 - f. To subscribe to the European Journal of Phycology at rates determined by Council and ratified at a General Meeting of the Society.
5. Every person on election shall pay to the Hon. Membership Secretary or the Hon. Treasurer, within one month, the annual subscription for the current year, such payment to entitle the member to all privileges of the society for that year. The first subscription paid by any member joining the Society within the last two months of the calender year shall also cover the succeeding year.
 6. Resignation of membership shall be signified in writing to the Hon. Membership Secretary, but the member so resigning shall be liable for payment of the annual subscription for the current year, together with arrears due.

ANNUAL SUBSCRIPTION

7. Annual membership Subscriptions and subscriptions to the European Journal of Phycology (for those members wishing to receive the Journal). shall be payable in advance and shall be due on the 15 January each year. At the discretion of the Council, reduced subscription may be paid by the following categories of members:-
 - (i) Student members (undergraduate and post-graduate) for a maximum for four years.
 - (ii) Members retired from full-time employment.

Changes in subscription must be ratified at a General Meeting of the Society. Subscription rates shall be publicised in the Journal and all relevant publications of the Society.

8. If any members shall be in arrears of his/her subscription for six months the Treasurer shall advise the member of the fact and, if payment is not made before the end of the subsequent period of six months, the member's name may be removed from the list of members.

COUNCIL

9. The business of the Society shall be conducted by a Council of members consisting of the six officers of the Society, namely: The President, the two vice-Presidents, the Honorary Secretary and the Honorary Treasurer, Honorary Membership Secretary together with the

- immediate past-President, the Honorary Editors of the "European Journal of Phycology" and the Newsletter (both ex-officio), and not more than nine Ordinary members of the Council; nine to constitute a quorum. All members of the Council, except the immediate past-President, the Hon. Editor and the Membership Secretary shall be elected by postal ballot, the result of the ballot being declared at the Annual General Meeting (see clause 14).
10. a. The President and the two vice-Presidents shall be elected annually, and shall be eligible for a second consecutive year of the same office. The retiring President and the vice-President shall not be eligible for re-election for the same office until an interval of three years from the expiry of the term of office. The immediate past-President shall continue to serve on Council (ex-officio) until succeeded by the next retiring President.
 - b. The Hon. Secretary, the Hon. Membership Secretary and the Hon. Treasurer shall be elected for a period of three years, and on retiring shall be eligible for re-election for a further three year period up to a maximum of three consecutive three year periods (with effect from January 1964 in the case of the Hon. Treasurer, and from January 1965 in the case of the Hon. Secretary).
 - c. In the case of the first Council to be elected in accordance with these rules, three Ordinary Members of the Council shall be elected for a period of one year, and three for two years. Thereafter, Ordinary Members of the Council shall be elected, normally in groups of three, for a period of three years. Retiring Ordinary Members elected in this way shall not be eligible for re-election to the same office until after an interval of two years from the expiry of the term of office. An Ordinary Member of Council, if elected to any other office on the Council, shall cease to be an Ordinary Member of Council. Ordinary Members elected for one year to fill a vacancy shall be eligible at the end of the year for immediate renomination as an Ordinary Member (for the usual three year period).
 - d. The Hon. Editors of the "European Journal of Phycology" and the Newsletter shall be elected annually by the Council.
11. The Council shall have the power to co-opt any Member of the Society to fill vacancies occurring during the year in Council, the tenure of such co-opted members shall terminate at the Annual General Meeting.
 12. The Council shall have the power to appoint for any special purposes sub-committees consisting either wholly or in part of Council Members.
 13. At the request of any three members of the Council, the Secretary shall convene a meeting of the Council, stating the nature of the business to be discussed.
 14. Election of Council: Any member of the Society may nominate candidates, who shall be Members of the Society, for the election as President, Vice-President, Hon. Secretary, Hon. Treasurer, Hon. Membership Secretary or Ordinary Members of Council.

All such nominations, with the name of a seconder, and with written consent of the nominee to act if elected, shall be forwarded to the Secretary not later than two months before the Annual General Meeting. If no nominations are received for any of the offices becoming vacant on the council, it shall be the duty of the Council to make such nominations. Voting shall be by postal ballot and for this purpose the Secretary shall circulate to all members of the Society, one month before the Annual General Meeting, a ballot form listing all

nominations for vacant offices on the Council. The completed ballot forms shall be returned to the Secretary in a sealed envelope bearing the signature of the member on the outside, before the Annual General Meeting; at that meeting the ballot forms shall be opened and the count made by scrutineers appointed by Council, and the results of the ballot declared. Any problems arising through nominees for Council receiving the same number of votes will be resolved by a further vote of the members present at the Annual General Meeting.

MEETINGS

15. The Society shall hold one or more meetings each year, and one of these meetings shall be the Annual General Meeting. Thirty-five members shall constitute a quorum for an Annual General Meeting.
16. Notices of all general meetings shall be sent to each member by the Secretary at the earliest possible date, and the agenda of the meetings shall be sent out at least two weeks before each meeting.
17. At the Annual General Meeting members of the Society present shall consider any business brought before them by the Council, or by any member (of which four weeks' notice in writing has been given to the Secretary).
18. The President, or in his/her absence one of the vice-Presidents, shall be chairman at all meetings of the Society; in the absence of any of these officers another officer or members of the Council. At any meeting of the Society the chairman shall decide as to procedure and the order of business. It shall be within the chairman's discretion to admit communications or other business, other than alterations to the rules not included in the programme.

In the case of equality of votes at any meeting of the Society or of the Council, the chairman may exercise a second or casting vote.

19. Finances: It shall be the duty of the Hon. Treasurer to prepare annual accounts as prescribed by current legislation. The annual accounts shall be examined by an Independent Examiner, who shall be an independent person who is reasonably believed by Council to have the requisite ability and practical experience to carry out a competent examination of the records. Copies of the annual accounts and the Independent Examiner's Report shall be circulated to Members together with the Agenda for the Annual General Meeting. The Independent Examiner shall be elected for the ensuing year at the Annual General Meeting.
20. Minutes: The Council shall cause Minutes to be duly entered in the books for the purpose of recording: all the appointments to the Council; the names of the members present at each meeting of the Council; and the proceedings of these meetings, the proceedings of the Annual General Meeting and any other special meeting.

HONORARY MEMBERSHIP

21. At any general meeting of the Society, after nomination by the Council, persons who have rendered conspicuous service to the subject of Psychology or to the Society may be elected Honorary Members of the Society. Honorary Members may have all privileges of membership as defined in Clause 4 of this constitution together with free receipt of the

Journal.

ALTERATIONS TO THE CONSTITUTION

22. No alterations to the constitution and Rules shall be made except at the Annual General Meeting, or at a special meeting of the Society called by the Council for that purpose. Notice in writing of any proposed alterations shall be given to the Secretary at least six weeks before any such meeting, and the proposed alterations shall be circulated to members with the agenda for that meeting. No alteration shall be made unless two-thirds of the members voting at the meeting are in favour of it. Notwithstanding the foregoing, no alterations may be made to this constitution that shall cause the Society to cease to be eligible for registration as a charity at law.

DISSOLUTION OF THE SOCIETY

23. The Society may be dissolved, after one year's notice in writing to all members, by postal ballot in which the majority of all paid-up members who vote, shall be required to affirm the motion to dissolve the Society.

The funds remaining to the credit of the Society at the time of dissolution shall be distributed to one or more other societies being constituted as charities and having similar aims to the British Phycological Society; the selection of these societies being the duty of the Council of the British Phycological Society at the time of its dissolution.

BPS FIELD MEETING, ISLE OF WIGHT, 1993.

In September 1993 the British Phycological Society held its annual field meeting on the Isle of Wight. The group was met by Bill Farnham at the railway pier at Portsmouth. Some of us had travelled long distances, from Ireland, Scotland and even Spain. We were a mixed group of professionals, students and amateurs. We had come from various institutions including English Nature, JNCC, Severn Rivers Authority, The Royal Botanical Gardens Edinburgh, environmental consultants, universities in the UK and Spain and even the local aquarium.

We travelled over to the Island by hydrofoil and stayed in a centre normally used for school field trips. During our stay we collected from a wide range of sites. On our first evening we studied the sandy shore at Cowes where there was a range of seaweed species growing over boulders. We also visited the sandy shore at Osborne Bay beside Queen Victoria's bathing hut where the seaweed was epiphytic on *Zostera*. Our accommodation centre was close to the Medina river. We visited this river very early one morning and found a very impoverished seaweed community but there was plenty of mud and some of us got very stuck! This mud, however, was of great interest to those in the group working on diatoms. Later on we visited Bembridge ledges, a rocky shore with deep pools. A salt-marsh area was also visited. One of our group, who owns the local aquarium, kindly invited us along to it, and we managed to squeeze a short tour into our packed program. It proved to be a fascinating experience which I would recommend to anyone visiting the island.

Each day had a very early start in order to catch the first low tide. On our return to the laboratory we sorted through the seaweed specimens we had collected. In the afternoon we visited additional sites and after tea we again worked in the laboratory. We studied the specimens and tried to identify them using field keys. Various volumes of Seaweeds of the British Isles were in constant use including the most recently published volume dealing with the Ceramiales (by Christine Maggs and Max Hommersand). We all worked together on the identification of the seaweeds and as a result much information was exchanged. We benefited from the expertise of individual members of the group. For example, Margaret Steentoft showed us how to distinguish between *Gracilaria verrucosa* and *Gracilariopsis longissima* and I helped with the identification of *Ceramium*. Some of the seaweed we identified ourselves using field keys. For example, *Hypoglossum hypoglossoides* was identified by its pointed blades, the presence of a midrib, branches arising from the midrib margin and the absence of veins.

The highlight of the field meeting was a visit to a salt-marsh area where the sole alga to be protected by the Wildlife and Countryside Act, the Charophyte *Lamprothamnium papulosum*, was growing. Access to the site was difficult because the path around the lagoon had become overgrown. We set off across the fields and over barbed wire fences, and then had to get back down to the shore by hacking our way through a thick forest. Unfortunately, we disturbed a bee's nest and several members of the group were badly stung. Eventually we arrived at the lagoon where we were able to see *Lamprothamnium* growing. With its whorl-branches it was very attractive, and made the lone trek worthwhile.

This field trip combined visits to different habitats with studies in the laboratory. We had to work hard from early in the morning to late at night with no time to go to the pub! Despite this, I think we all enjoyed ourselves and we came away a great deal more knowledgeable about the seaweed flora of the British Isles.

Barbara Ward,
The Queen's University of Belfast.

SEAWEED IDENTIFICATION COURSE.

University College, Scarborough, North Yorkshire.

22-25th July 1994.

Course Organisers: Dr. F.G. Hardy and Mr. G.W. Scott

After two successful BPS field meetings, at Anglesey (1992) and the Isle of Wight (1993), a third course is to be held in North Yorkshire in an area of great phycological interest. These meetings offer an excellent opportunity for those who wish to increase their knowledge of the seaweed flora of British shores. The species list that is obtained from the course will be fully written up in *The Phycologist* with a report on the proceedings.

The Course will run from Friday evening (22nd July) until after breakfast on Monday morning. Accommodation and laboratory facilities will be provided by University College, Scarborough. It is intended that several areas of the shore will be visited such as Robin Hood's Bay, Filey Brig and Flamborough Head. The course will be tailored to the interests of the participants, and will be suitable for both beginners and experts, amateurs and

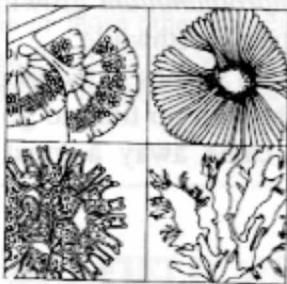
professionals. Cost of accommodation will be £50:00.

It would be helpful if intending participants could indicate whether they could offer seats in a car (so that transport costs can be kept at a minimum and shared, by paying for petrol). If necessary a minibus will be hired for the weekend (and the cost shared). A decision will be made closer to the date of the course.

Further details are available from Dr. F.G. Hardy (Department of Marine Sciences and Coastal Management, University of Newcastle, Newcastle upon Tyne. NE1 7RU. Tel No: 091 222 6661 Fax No: 091 222 7891) and Mr. G.W. Scott, to whom all bookings should be sent (University College, Filey Road, Scarborough. North Yorkshire. YO11 3AZ. Tel No: 0723 362392 Fax No: 0723 370815). An application form can be found in the middle pages.

SOCIETY T-SHIRTS AND SWEATSHIRTS.

The British



Phycological
Society

The Society's T-shirts and sweatshirts bearing the design illustrated are available by mail order. T-shirts, with a coloured design, are available either in white cotton or unbleached raw cotton. Sweatshirts are available either in unbleached cotton, with coloured design, or red with black design, or in either navy blue, green or black with white design. These coloured sweatshirts are either in 100% cotton, when available, or else in cotton/poyester. (Green ones are always cotton/polyester).

The sizes quoted are not very generous and it is advisable to order a larger size than you might first think. Judging by the sales made at the Liverpool meeting, a "Medium" fits a small lady/teenager, a "Large" would fit an average lady/small man. The child's size is probably only to age 8-9.

The Society does not keep stock of these items - they are made to order and will be despatched from the supplier. Refunds can only be made for faulty goods, not for incorrect sizes. An order form can be found in the middle pages.

REPORTS FROM THE WINTER MEETING OF THE SOCIETY

Penny Lane Ponderings

The 1994 B.P.S. Winter Meeting was characterised by typical Liverpoolian hospitality. This even extended to removing the doors from the W.C. cubicles in a bath/shower room on at least one floor of the residence; fortunately this was the only aspect of the meeting which was unhinged or in which screws were loosened to the point of removal.

Much excellent phycology was presented to us in the lectures and posters. Any selection of highlights must be subjective and based on incomplete coverage by an individual due to the scheduling in part of parallel sessions. I was obliged (as a judge) to attend the Manton Prize lectures, and was most impressed by the standards of science and presentation; it would have been difficult for the parallel sessions to have bettered them! The Manton Prize standard was certainly much better than my early (and some of my later!) presentations to learned societies.

Introduced as having some hard acts to follow in the form of previous Founders Lecturers, Klaus Luning's presentation was an object lesson in clarity, modesty and insight in reviewing a complex and very important topic. The next Founders Lecturer has certainly been set a very high standard to live up to.

The applied phycology aspect of recent winter meetings was continued and it was gratifying to see that some of the applied phycologists stayed on after 'their' symposium had ended.

Those who attended the AGM will have been gratified to hear of good progress in the first year of the 'Europeanised' *Journal*, and in publication, and commissioning of a further part, of the *Marine Flora*. The *Freshwater Flora* is also progressing; I am very eager to see the volume on freshwater red algae to clarify my interpretation of some of these fascinating organisms.

Finally, thanks to all the native and adopted scouces who did so much to make the meeting so successful (I especially appreciated Joanna Kain's efforts in florideophyting the name badges), and to the European, North American and South African contributors who added to the British perspective. I enjoyed this one so much that I think I'll go to the next Winter Meeting!

J A Raven
University of Dundee.

A students view.

1994 opened with another BPS conference, this year held in Liverpool. Tuesday evening kicked off the meeting with a fine display of posters covering just about every imaginable field of algal research from biochemistry, taxonomy, reproduction and even a poster on the

wonders of $^{13}\text{C}/^{12}\text{C}$ discrimination by phytoplankton.

A faulty slide projector, with a mind of its own, would have threatened to spoil Wednesday mornings session on eutrophication. However, the likes of Bailey-Watts, Brierley and Wilkinson remained calm and carried on to deliver some interesting talks, barely noticing the jumping, spluttering projector. For the afternoon talks, I chose to stay in the session on algae and conservation, a topic which would seem somewhat controversial after the previous talks on eutrophication! All the talks were very informative and really highlighted the fact of how little attention is focused on conserving this aspect of the marine environment.

Wednesday's evening meal was certainly an improvement over last year's conference, judging by the extra numbers of people who attended it!!

On Thursday I opted for the Manton Prize sessions. I was amazed at the quality of the presentations and the calmness of the speakers. They certainly set me panicking to think of the high standards which I'll have to meet when I give a talk next year. Congratulations to Ester Serrao for winning the prize.

In the evening we all sat down to the BPS dinner, another delicious meal, followed by the auction. Although not quite as riotous as last years auction, this one still proved good fun allowing us to purchase various SEM's, sweatshirts, more pictures, more sweatshirts and um.... Yes, the auction was slightly lacking in species abundance! Afterwards, everyone gathered in the bar for much drinking and chatting. Those brave enough went on to one of Liverpool's finest nightclubs (the Yazz?) and the real party animals (D. Harris) even managed to sniff out a party.

Friday morning saw the last and in my opinion the best of the talks. I went to the physiology session to listen to the excellent talks of my colleagues and discover what our group is up to! Due to a long journey back to Scotland, I left the talks early, though the 8 hours it took to reach home gave me plenty of time to reflect on what a success this year's meeting had been. In addition, I had my very own BPS t-shirt to remember it all by!

Rebecca Korb,
University of Dundee / Dunstaffnage Marine Lab.

A lot happens at a Winter Meeting!

Tuesday 4th January: leave a very dark Dundee at 07:22 wondering if British Rail can get me to Liverpool for the Council meeting at 14:00! B.R. does the trick, only two changes of train and I arrive at Lime Street Station at 13:25. Liverpool isn't too far from Dundee really! I bumped into another council member, Peter Robinson, at the ticket barrier and we made our way to the Derby and Rathbone Halls of residence, thank goodness I remembered my map. As a relative newcomer to Council my impression was that our meeting went well;

everyone seems to reach agreement on issues much more quickly than any other committee I have served on, long may this continue.

Following the Council meeting I tried to track down my students to see if they had arrived and managed to get their posters up. The posters were there but no sign of the students. As the bar was not open until later in the evening it was off to try the local. A Liverpool student recommended the Finch and Firkin, a brew pub some half mile down the road. It turned out to be a huge place with a fine range of real ales, so I was obliged try to one or two. This was followed by the Poster session and the return of my students. They had been to a Wine bar in Penny Lane, a street made famous by the Fab Four before Jennie, Beki and Peter were born!

And so to work. The posters were held in the same room as the buffet so it was eat and work. As usual there was a good mix of posters ranging from the taxonomic through the physiological to the biotechnological. As will become apparent from this report my physiological interest is concerned with the photosynthetic physiology of micro- and macroalgae. Having worked on *Fucus serratus* I was particularly interested in Scott and Hardy's poster on the hybrids of *Fucus* species and I concluded I will look a little more closely at *Fucus* plants to see if I can spot the hybrids myself. Also of interest was the work of Strbac and co-workers on the ultrastructure and photosynthetic activities of deep-sea and subtidal *Laminaria* sp. as the research group I am in is investigating the acquisition mechanisms of inorganic carbon in relation to photon flux density. Between them Matt Dring, Rod Forster and Rainer Schmid have done a lot of excellent work on the effect of red and blue light on photosynthesis in a range of macroalgae so I was glad to see Rainer had a poster as well as oral paper. Rainer did his best to whet my appetite for his paper by suggesting the paper contained all the good stuff. As the poster session began to break up I came away thinking that next year I would have to try my hand at a poster. I have only presented one previously and if the Society has to limit the number of oral presentations to one per person (because of numbers) then the poster looks like the way to put one or two of my wilder ideas out to play. After the posters it was back to the Finch and Firkin with the lab to try one or two more of the ales.....

Next morning started with my now annual reunion with school-type food, peeled tomatoes, fried eggs, sausages, bacon and toast washed down with large amounts of tea. This is only once a year so my digestion finds it an interesting experience. Spent the rest of the morning wondering if it was worth it.

The Society organised special sessions on Eutrophication and Conservation (J. Brodie) and Measuring Algal Growth in natural populations (M. Dring and E. Cox). There were a large number of excellent papers but I can only mention a few.

A. Bailey-Watts (IFE, Penicuik) started us off on a session entitled Approaches to the monitoring and management of eutrophication in fresh waters. C. Gibson (Dept. Agric., Belfast) gave a thought provoking paper with the use of a functionally challenged remote projector system. He suggested that through the use of a simple model the sinusoid relationship between chlorophyll and total P concentration could be described and that this data could be used to define sampling strategies.

This session was followed by Eutrophication and Conservation. The first paper was given by Dave John (NHM, London) who in the space of 20 minutes covered a large area linking conservation with biodiversity and eutrophication. Dave reported on the various responses to the Rio Summit by both government and non-governmental bodies and the criteria they use. He raised the topic of Terrestrial chauvinism in that the marine system holds representatives of 28 major phyla where as there are only 11 on land. Dave had

planned to write a full report of his paper for the Phycologist but for reasons outside his control, he was called away to South East Asia at a day's notice, his piece should appear in the next issue. B. Moss, our host at Liverpool, started his talk by showing a water quality map of Cheshire with rivers marked on a scale of 1-4. He then compared the water profile of two lakes and then contrasted their degree of eutrophication using the standards of OECD and English Nature. He concluded that there must be a better way and reported on his work with the NRA to produce a scheme for classifying and monitoring lakes based on a Value Change Statement, describing how a water body has changed from a fixed baseline point. Prof Moss finished off by apologizing that in his talk he had hardly mentioned algae, but concluded that as physicists can spend time discussing black holes, which consist of no matter, an algologists should be able to talk without mentioning algae! R. Mitchell (English Nature) gave a paper in which he explained the structures that are in place to aid conservation in England and Wales, Scotland I noted was again a special case with its different law. I think Roger really highlighted one of the key roles the Society has to play in the next ten years. He compared the activities of "The National Dormouse Week" with algae and concluded that although the dormouse is well cared for there is no equivalent from the algal phyla. This was partly because we, as working phycologists, are not certain if there are any algae in danger. There are a number of protection schedules and sites for protection but there are few, if any, which include algae. The story of how the coast of Kent was saved by various groups from wall to wall concrete was given by I. Tittley. He gave two examples of how the Society had given evidence to public inquires in order to preserve sites for algal conservation in Ramsgate and Botany Bay, the site of the first marine SSI. In his second paper he showed how species lists, 33 of them covering the north Atlantic, are used in conservation and action for biodiversity when national assessments are being considered. Ian again highlighted the work the society is doing in the international arena. C. Maggs (Queen's, Belfast) gave us a geography, history and phycology lesson all in 20 minutes when describing whether *Antithamnion densum* was an introduction or native to the North Atlantic. She concluded that it was not an alien seaweed but that *A. spirographidis* was likely originally from the North Pacific. N. Stewart (Dublin) completed this session with a description of how a Red book is compiled and was able to hold up the Red Book for Stonewarts. I found the sessions on Algae and Conservation a lot more interesting than I thought they were going to be, being a heads down physiologist. What impressed me most was how important the work is and how much work there is to do. With the end of the session it was off to the pub and a dinner with the lab.

The next morning, Thursday, started with a bang, the Manton prizes from post-graduate students. The papers were of a very high standard covering a wide range of phycological areas. Elsewhere in this newsletter Len Evans has written a report on the winner, Ester Serrao. Ester gave an excellent paper and was well worth the prize. Other papers I enjoyed and found interesting were those by A. Harris (*Thalassiosira* sp. from a Scottish sea-loch); B. Hitchings (ecophysiology of *Scenedesmus*); Barker (genetic diversity in *Emiliania huxleyi*) and B. Ward (species complexes in the genus *Ceramium*).

At mid-day the 3rd Founders' Lecture was presented by Prof. Klaus Luning (Helogland, Hamburg). I found this a particularly good paper because of my interest in macroalgae and scuba diving. Klaus told a lovely story of his first dive from Helogland with the whole institute watching; Klaus found that he had forgotten his weight belt. More importantly Klaus gave a well paced explanation of the thinking and stimulus behind his research. What struck most clearly was the impact members of the Society had in influencing his important work on the development of macroalgae. I just hope that in years to come the

Society will continue to stimulate phycology outside the shores of the UK. The afternoon session was highlighted by PML work on the life history of *Emiliania huxleyi* (J. Green). I had meant to go to G. Russell to hear about *Pilayella littoralis* but I misread the timetable and rolled up late, must try harder.

Thursday night means two things, the AGM and the conference dinner. The AGM was one of the quicker ones I have attended and again business was dealt with very agreeably. The conference dinner was in my opinion one of the best in recent years, mainly on the food front. It was slightly spoilt for me in that Matt Dring roped me to help with the auction. This went surprisingly well considering we had a lot of repeat items to get through, sweat shirts and Manton prints, some of which went for a fine price. I think there must have been some cruel planning afoot as both Matt and I were giving the first papers on Friday morning. I cut the night slightly shorter than normal so I would get a good nights sleep in order to be fresh the next day. My head hit the pillow at 01:30....

Up with the larks.... my paper went well despite the return of the dysfunctional slide projector. I then sat down to listen to the remaining talks in my session from John Raven, P. Robinson and C. Heath. It was interesting to hear how Carolyn's work had progressed since she was last years Manton prize winner. I finished off my time at Liverpool chairing the final session on the physiology of macroalgae with papers from R. Schmid (Belfast), J. Kübler (Dundee), J. Kain (Liverpool), G. Pearson (Maine) and Forster (Helgoland/Rostock). I have to admit I found this the best session of the meeting, so much so that I frequently forgot I was chairing the session when the speaker had finished. The papers were really well presented and they stimulated some particularly good questions.

After a quick council meeting and quicker lunch it was goodbye to Liverpool and off to Dundee. All in all an excellent meeting and I can recommend future gatherings to anyone interested in phycology, what ever their alga.

Andrew M. Johnston
University of Dundee

THE IRENE MANTON POSTGRADUATE PRIZE IN PHYCOLOGY, 1994.

At the January 1994 Meeting of the Society there were eleven contenders for the Manton Prize for the best paper given by a postgraduate research student (see The Phycologist, No 36, November 1993, pp 17-18) and a panel of six evaluators assessed each talk for scientific quality and clarity, visual impact, oral clarity, timing etc. The overall standard of the science and the presentations was high, but in the opinion of the judges the best paper was given by Ester Serrao from the University of Maine. Her contribution, with Drs L. Kautsky and S.H. Brawley was entitled "Fertilization ecology of *Fucus vesiculosus* in the Baltic Sea".

Ester Serrao was born in Lisbon, Portugal, in 1966. After concluding her degree in Biology at the University of Lisbon in 1989, she obtained a Master's degree in Probability and Statistics at the same University in 1992. In 1990 she started a tenure-track position at the University of Algarve, Portugal, where she teaches Marine Botany. Since 1993 the University of Algarve has granted her a leave of absence for PhD studies at the University

of Maine, USA. She has a Fullbright fellowship (USA) and has also won several fellowships from European institutions. After completing her PhD she plans to return to the University of Algarve to conduct research in phycology and to continue teaching Marine Botany.

We wish our prize winner well in her future research career.

Prof L.V. Evans.
University of Buckingham

NOTES FROM THE 1994 AGM

Full minutes of the 1994 AGM will be published in the third (autumn 1994) issue of the Phycologist, with the programme for the next winter meeting.

Future winter meetings:

It is now necessary to plan these reasonably far in advance to guarantee accommodation and lecture theatres.

1995 - University of Portsmouth (Jan.4th-6th)

1996 - University of Lancaster

1997 - It has been proposed to meet in Plymouth, subject to confirmation.

Offers to host future meetings are always welcomed by Council.

Council officers and members:

Dr Jane Lewis has retired as Treasurer. Dr Lynne Terry will be the next Hon. Treasurer. The President thanked Jane for her work over the last three years and for steering the Society's finances through some difficult times with falling interest rates, different banks and seeing three changes in subscription rates through. She has left us in good shape.

Dr Eileen Cox has agreed to serve another 3 year term as Hon. Secretary.

Dr Stephen Droop was formally elected as Hon. Membership Secretary.

Dr Roger Jones retired as Hon. Editor-in-chief of the journal and handed over to Dr Christine Maggs. Roger served as Editor for seven years and has seen the completion of the first year of the new European Journal of Phycology, which seems on the whole to have been favourably received.

Thanks were expressed to three retiring ordinary members of Council:

Dr Juliet Brodie, Dr Gavin Hardy and Dr Philip Wright. They have all been active on behalf of the Society and their work is much appreciated.

Two nominations for new members of Council were received. In the absence of a third nominee, Council made a nomination, thus the following were welcomed as ordinary members:

Dr Stephen Maberly, Dr Judith Taylor and Mrs Jenny Moore.

Newsletter:

Dr Robert Edyvean has retired as Editor of the *Phycologist*, but remains as an associate editor. Thanks were expressed for all his work over the last six years or so. Dr Andrew Johnston is the new editor. (Other details on the cover of this issue).

Membership matters:

Mr Stephen Droop reported that it is hoped to produce an address list of members which will be published in the *Phycologist* later this year. This would incorporate corrections to addresses and research interests requested in the recently circulated questionnaire.

Sadly the death of one of our Honorary Members, Mr John Carter, was reported. He had a stroke in October 1993 and died the following month. Our sympathy goes to his children and their families.

Constitution:

Modifications to the Constitution were approved by the AGM. Most of the changes are related to changes in the name of the Journal, some of the responsibilities of officers and membership categories. The modified version is published in this issue of the *Phycologist*.

Moves towards a European Federation:

There have been positive responses from five other European Phycological Societies towards receiving the *European Journal of Phycology* at members' rates. We hope this trend will be maintained and help raise sales of the journal.

It is proposed to hold the 1st European Phycological Congress in Cologne, Germany, from 11-18 August 1996. Prof. Michael Melkonian has agreed to head the organisation of this meeting.

T-shirts / Sweatshirts:

BPS T-shirts and sweatshirts were produced for the meeting and have been selling well. Orders can be placed if your size or colour has sold out. Thanks were expressed to Stephen Droop and Lynne Terry for their work.

Report on the European Journal of Phycology Management Committee (EJPMC).

The suggestion to create a committee with the aim of managing the business and production affairs of the *European Journal of Phycology* was first discussed at the July 1992 Council meeting of the BPS. It was agreed that the committee should be made up of the editor-in-chief of the Journal, the treasurer of the society and two other members, and that it would have the authority to make decisions without necessarily approaching the council.

The first meeting of the EJPMC was held on the premises of the Cambridge University Press on the 6th April 1993, where the terms of the reference for the committee were drawn up (which were subsequently approved by council on 4th January 1994), and a number of topics were discussed. Particular consideration was given to the initial reactions to the first issue of the *European Journal of Phycology*. The overall response to this issue was favourable, with only minor changes in style being necessary. Other subjects that were covered included

subscriptions, impact factor ratings, promotion, marketing and publicity, and special issues of the journal. The committee was also supplied with "best" and "worst" case scenarios of financial forecasting by CUP.

The committee is currently composed of Dr. Christine Maggs, (editor-in-chief), Dr Lynne Terry (Hon. Treasurer), Professor Len Evans (chairman) and Dr. Juliet Brodie (secretary). They would welcome any comments/suggestions with regard to aspects relating to the management of the journal. The committee meets again on 29th March 1994.

Report on the BPS Conservation Committee.

There has been a feeling in recent times that the BPS should become more actively involved in algal conservation. One of the consequences of this was that the recently reformed BPS Conservation Committee met on 5th January 1994 during the BPS winter meeting at Liverpool. The committee was chaired by Dave John, and was fortunate to be joined by two observers, Claire Eno from the Joint Nature Conservation Committee, and Nick Stewart for the National Parks and Wildlife Service, Dublin.

The meeting proved to be wide ranging in content, although some key points did emerge. There was general agreement that the committee should be in a position to respond to matters relating to algal conservation when approached, as has been done in previous years. They should also become involved in certain conservation issues and support various conservation bodies where necessary. The BPS should be ready with scientific information when conservation issues arise. The committee should see through such projects as the marine algae mapping scheme and instigate action for endangered algal species.

The members of the Conservation Committee would value any information, comments and suggestions in relation to algal conservation. Information on alien introductions would be especially welcome. Correspondence should be sent to Dave John, (Natural History Museum, Cromwell Road, London. SW7 5BD).

Members of the Conservation Committee include Juliet Brodie, Gavin Hardy, Dave John, Brian Moss, Jacqueline O'Mahony, Harry Powell and Sue Scott.

Report of the Membership Secretary.

As at the end of 1993 the membership of the BPS was as follows (numbers indicate "paid up/in arrears"):

	U	E	N	R	Total
Ordinary	145/12	106/12	93/16	74/12	418/53
Student	36/13	4/1	2/2	9/-	51/16
Retired	19/-	8/-	7/-	5/1	39/1
Honorary	8/-	-/-	-/-	-/-	8/-
Assoc. (no EJP)	19/3	5/2	2/-	5/1	31/6
Sub-totals	227/29	123/15	104/18	93/14	547/76
Totals	256	138	122	107	623

U = UK; E = rest of Europe; N = North America; R = rest of the World.

1993 has been a good year for new members: 60 joined for the first time, and another 4 former members rejoined. This shows a healthy increase in a new intake over 1992, and that Peter Robinson's marketing efforts are being rewarded.

Losses were lower than 1992: 14 members resigned, but only 39 were struck off for non-payment (compared to 56 in 1992). It was with regret that we learnt of the death of 5 members during the year: Robert Hoshaw, Peter Dixon, Mike Neuschul, Peter Kornmann and, most recently, John Carter. Members will remember that John was elected as an Honorary Member at the winter meeting in Swansea last year.

Notice that the membership summary is broken down geographically. Interestingly, this shows that only 256 out of 623 members (41%) are resident in the UK, whereas 49 out of 67 *Student* members (73%) are. The breakdown also shows that a greater proportion of members resident in North America are in arrears with their subscriptions than those elsewhere. Tut, Tut!

1993 has seen the computerization of the membership records- not a completely painless process, but so far free from major cock-ups! This event has certain implication for members:

Firstly, there is now only one official version of the membership records --- address labels for all society mailings including the Journal are produced from this computer. If you have a change to make, please notify *me* to save time, not CUP or any other society office-bearer.

Secondly, all subscriptions are now handled by the Membership Secretary (i.e. *me* again) and not the Treasurer, who has enough to do arguing about VAT and interest rates!

Thirdly, we can now produce a membership list straight from the computer. But, of course, this can only be as good as the information in it. So PLEASE fill in/correct as necessary the slip you were sent before Christmas (the one on the back of the piece of CUP label paper, in the same mailing as the bright green subscription-renewal form) showing the how your membership details are held on the computer, and RETURN IT TO ME. We particularly want to include E-Mail addresses and research interests. For research interests we are following the subject categories listed inside the front cover of the journal, with an additional "Other" field, but please specify what sort of "Other" if you use this category.

The membership list will be published in the Summer issue of *The Phycologist*, so I need to have any amendments *well before* the copy deadline (May 31), so please get them to me by **April 30** at the latest.

S.J.M. Droop
Hon. Membership Secretary

Report of the Hon. Treasurer.

First of all I would like to thank Jane Lewis, the retiring Hon. Treasurer, for her stewardship of the Society's funds for the last three years and for her help with the hand-over.

Banker's Orders:

One consequence of the change in Hon. Treasurer has been a change in banking arrangements. This, coupled with the changes in subscription rates, means that it is important

that everyone who pays by Banker's Order must update their arrangements. If you have not already done so, a form is included.

Charges on US\$ cheques:

Banks are now charging high fees for cashing overseas cheques - 5 pounds per transaction. Council decided that some time ago that members wishing to pay by US\$ cheque should bear these charges. Regrettably, I have to ask that if you send money in this way that you add £5, to the total sterling value prior to conversion to dollars. An alternative, cheaper, way to pay is the credit card (see below).

Credit card payments:

The Society is able to accept the following credit cards for payment of subscriptions, back copies of the Journal or for T-Shirt orders: **VISA, MASTERCARD AND EUROCARD**. Again, the Society asks that you add sufficient to cover the charges incurred, in this case currently 90p per transaction. A credit card form is reproduced for your use.

Cheques:

When sending cheques to the Society subscriptions, T-shirts, or back copies of the Journal please make the cheque payable to "The British Psychological Society". Please do not make cheques payable to individual officers or to the Journal (it does not have a bank account).

Subscriptions:

Subscriptions are processed quicker if you send them to Stephen Droop, the Hon. Membership Secretary rather than to me. The 1994 rates will be held for 1995.

The new rates are:

	1994/5	1993
	£	£
With Journal		
Ordinary Member	25.00	20.00
Student Member	20.00	15.00
Retired Member	20.00	15.00
Without Journal		
Ordinary Member	10.00	10.00
Student Member	5.00	N/A
Retired Member	5.00	N/A

NEWS.

If there is anything you would like included in *The Psychologist* please write to me and I will endeavour to publish it. I am keen on passing on the word about our members, their coming and goings, such as getting jobs, completing PhD's, interesting visits planned and new arrivals!

I would like to start by congratulating Jane Lewis and George Rowing on the safe arrival of their daughter, Elinor Mary, on 9th March 1994, vital stat, 9 lb 2 oz, heavy girl. As most of you will know Jane was our past Treasurer and I wish her all the best happiness. I write this as a first time father of a six month baby boy.

The Botanical Society of America has written to the Society asking for nominations for the Darbaker Prize in Phycology for 1994. The prize will be awarded at the next annual meeting of the BSA in Knoxville, Tennessee. The award is for meritorious work in the study of microscopic algae, is limited to residents of North America, and is based only on papers published in the English language. Nominations must include (i) a statement describing the nominee's meritorious work in the study on microscopic algae, (ii) an up-to-date CV for the nominee. The submitted materials may also include: (i) reprints and/or copies of any publications that should be considered by the committee (complete sets of all publications are not needed, however the inclusion of representative or especially important publications is strongly recommended); (ii) additional supporting letters corroborating the meritorious work of the nominee; and (iii) other evidence of the significance of the nominee's work on microscopic work. The materials including all additional letters, if any, must be submitted as a single packet by the **1 June 1994** deadline.

Please send nominations to: Dr Greta A. Fryxell, Chair, Darbaker Prize Committee, Dept of Oceanography, Texas A&M University, College Station, TX, 77843-3146. USA. E.Mail: Fryxell@Triton.TAMU.edu

Rod Forster has moved from Helgoland further east to Rostock and from what I hear will be leaving macroalgae for the delights of microalgae and cyanobacteria. I wish him well and hope he will write an article for the newsletter giving his impressions of the Ost.

Word has come that Matt Dring will also be going east, this time only to Helgoland, for as yet indefinite period of time to continue his collaboration with Klaus Lüning.

I would be grateful if someone would volunteer reports of the Phycological Congress (China) and the Seaweed Symposium (Chile) for the Newsletter.

J. ANDERSON, H. BENNION and S. GIGGINS (Danish Geological Survey; Limnological Institute, Mondsee; University College London).

Establishing background total phosphorus concentrations in nutrient enriched lakes: The use of diatom-based transfer functions. II. Implications.

Lake restoration by reducing nutrient loadings continues to be a major aim of many government agencies. Often, however, there is little if any background information available to indicate what predisturbance conditions were. Diatoms preserved in lake sediments, however, have provided a qualitative means of determining the history of lake enrichment for some time. With the development of weighted averaging inference models it is now possible to make quantitative inferences of what epilimnetic total phosphorus concentrations ($\mu\text{g TP l}^{-1}$) were, and when used in conjunction with ^{210}Pb dating, at a variety of timescales. Examples of diatom-inferred TP profiles will be given for a variety of lakes, with variable degrees and timing of enrichment. Comparisons of diatom-inferred TP and monitoring data will be made. Possible important error sources (both within the model and due to sedimentation effects) will be considered and the results of the diatom-inferences compared to those of empirical and mathematical models. The possible use of short-cores for monitoring lake recovery will be illustrated, and the general management implications of the approach discussed.

A. ASHTON. (Department of Animal & Plant Sciences, P.O. Box 601, University of Sheffield, Sheffield. S10 2UQ)

The effects of heavy metal contamination on benthic algal communities in flowing waters.

The effects of a coal mine discharge into the River Don, South Yorkshire on benthic algal communities was assessed over a twelve month period. Information on water and sediment quality, algal abundances and community structure was obtained. The contamination affected the communities in several ways: algal abundance and diversity was reduced whilst temporal patterns were affected. Desmids were eradicated although the abundance of other green algae increased.

Canonical correspondence analysis indicated that the main environmental factors associated with

shifts in community structure were iron, manganese and aluminium concentration. This analysis was used to classify species as either tolerant, indifferent or sensitive to the contaminating metals. Laboratory studies will investigate causal link between metal concentrations and these species in more detail.

These observations will be compared with those obtained from a study on the River Lathkill which receives discharges from a disused lead mine.

S. ATKINS and S. MATHIESON (Aquatic Environments Branch, Scottish Natural Heritage Edinburgh, UK)

A review of nutrient enrichment in the estuaries of Scotland: implications for the natural heritage

The present nutrient status of the Scottish firths is reviewed using monitoring data from the river purification authorities, governmental, and other sources. Conditions in these firths range from pristine, with no evidence of elevated nutrient levels, to a small number of sites which are highly nutrient-enriched. The geographical distribution of these sites, temporal trends in nutrient levels, and nitrogen fluxes in the systems, are described in relation to changes in land use and nutrient sources.

Results from a number of studies on the ecological effects of nutrient enrichment in Scottish firths are reviewed, with reference to the implications for the natural heritage interests of these sites. In particular, the potential knock-on effects of nutrient enrichment on the fish populations and the internationally important wader and waterfowl populations of Scottish firths is highlighted. The implication of the EC Nitrate Directive for Scottish coastal and estuarine waters and recommendations for future action to protect the natural heritage, are discussed. The Scottish National Heritage 'First Initiative' promoting integrated environmental management of the firths and estuaries of Scotland is introduced.

A.E. BAILEY-WATTS (Institute of Freshwater Ecology, Edinburgh Laboratory, Bush Estate Penicuik EH26 OQB, Scotland)

Freshwater eutrophication: approaches to its assessment, monitoring and management with phytoplankton as the main focus.

This is the first of three talks which collectively draw on eutrophication studies carried out in England, Northern Ireland and Scotland - all with

the ultimate aim of understanding the effects of enhanced nutrient enrichment on phytoplankton assemblages, and the application of the knowledge to the management of eutrophic waters. This talk will consider very briefly the following aspects: the distinction between eutrophication *per se* (nutrient loadings) and the biological manifestations of accelerated enrichment; contrasts and comparisons between different nutrient inputs; loading assessments; measurements c.f. desk studies; factors affecting algal biomass per unit nutrient input; phytoplankton sampling and enumeration; algal control.

J.M. BARICA. (Lakes Research Branch, National Water Research Institute, Burlington, Ontario, Canada)

Algae as indicators of ecosystem stability and sustainability.

Amplitudes of oscillations of algal biomass in eutrophic lakes provide a useful measure to assess the stability and sustainability of a lake's ecosystem. The maximum amplitudes are reached in hypereutrophic lakes which undergo collapses of Cyanophyte blooms as a result of unsustainable productivity, with the resulting breakdown of the structure and function of the system (anoxia, toxicity, fish kill). Algae provide warning signals during their development and indicate various levels of ecological sustainability.

Examples of conservation strategies from the Great Lakes Basin resulting in abatement and/or reversal of eutrophication trends are presented with instances where moderate eutrophication counteracts contamination of fish by toxic organic substances.

G.L.A. BARKER, P.K. HAYES, L.K. MEDLIN* and J.C. GREEN**. (School of Biological Sciences, University of Bristol, *Alfred Wegener Institut Bremerhaven and **Plymouth Marine Laboratory.)

Genetic diversity in *Emiliana huxleyi*.

Emiliana huxleyi (Prymnesiophyceae) has a cosmopolitan distribution, inhabiting both open ocean and coastal waters from polar to sub-tropical latitudes. Morphometric, physiological, biochemical and immunological studies support the division of *E. huxleyi* into two taxa, initially designated morphotype A and morphotype B (Young & Westbroek, 1991, van Bleijswijk *et al.* 1991). Comparison of complete small sub-unit ribosomal RNA (ssu rRNA) sequences from 3 widely separated type A clones with that of a type

B clone (Bhattacharya *et al.* 1993) reveals no more than a single ambiguous nucleotide position separating any of these clones. Similarly there are no sequence differences between the plastid *rbcL* *rbcS* spacer regions of 1 Pacific, 1 Indian Ocean and 3 North Atlantic type A clones, and 1 North Atlantic type B clone. By studying amplification fragment length polymorphisms (AFLPs) for clones from Norwegian Fjords and the N. Atlantic, we can detect population level genetic diversity, which is as great between clones from a single mesocosm bag as between clones from the Fjords and the North Atlantic. We conclude from this molecular evidence that the taxon *E. huxleyi* is monospecific, and that the level of genetic difference observed between clones does not correlate with their degree of geographical separation.

M. BEKLIOGLU and M. GENNER (Department of Environmental and Evolutionary Biology, University of Liverpool)

Blue green or Green algae, the effects of elevated pH/low CO₂. Preliminary results from an enclosure experiment in Little Mere, Cheshire.

The enclosure experiment was carried out to determine the effects of elevated pH/low CO₂ and fish treatments on the phytoplankton community in 27 polyethylene enclosures at high inorganic nutrient concentrations. pH levels were raised to 9, 10, and 11. Perch was used at three different treatment levels (0, 2, 4 fish per enclosure). Each treatment was triplicated. Chlorophyta and Cryptophyta predominated rather than Cyanophyta in all fish treatments at pH 9 and 10. At pH 11 neither fish nor zooplankton survived and algal numbers were negligible.

H. BENNION, S. JUGGINS and N.J. ANDERSON (Limnological Institute, Mondsee; University College London; Danish Geological Survey)

Establishing background total phosphorus concentrations in nutrient enriched lakes: The role of diatom-based transfer functions. 1. Theory.

Estimates of background TP concentrations in lakes can be determined by a number of methods, e.g. dynamic mathematical and empirical models. An alternative method is the use of the diatom record in sediment cores. Many diatom species have well known ecological distributions: e.g. *Asterionella formosa* in mesotrophic lakes, *Stephanodiscus* spp. in eutrophic lakes. These

qualitative ecological relationships can now be quantified using weighted averaging regression and calibration, where the TP optima and tolerance for individual species are determined from their distribution in surficial sediments from lakes with known nutrient chemistry. The use of Canonical Correspondence Analysis to determine the dominant relationships between water-chemical variables and diatom assemblages will be illustrated. Weighted averaging calibration theory will be described. Root mean standard error estimates for the TP-inferences derived from jackknifing and bootstrapping provide a better estimate of the true error associated with the approach. Transfer functions derived from the relationships between diatoms and TP concentrations will be illustrated for individual and combined training sets from England.

D.A. BIRKETT and M.J. DRING (School of Biology and Biochemistry, Queen's University, Belfast)

Relations between phosphate uptake and growth in macroalgae.

Rates of phosphate uptake were determined at intervals over a period of 18 months for three kelp species (*Laminaria saccharina*, *L. digitata* and *L. hyperborea*) and for *Palmaria palmata* growing as an epiphyte on *L. hyperborea*. Uptake rates by standard tissue samples were measured after 24-h pretreatment in a chemostat system either in continuous light ($115 \mu\text{mol m}^{-2} \text{s}^{-1}$) or in darkness. Seasonal changes in uptake rates after pretreatment in the light followed the same patterns as the annual growth cycles for all species.

In the early spring, when the growth of kelp plants was increasing, the rates of phosphate uptake by individual plants were correlated with the subsequent rates of growth of the same plants in the field. Within individual plants of *L. saccharina*, the rate of phosphate uptake by tissue from different regions of the blade was also correlated with the growth rate of the tissue during pretreatment, and both rates decreased in older tissues.

The difference between the uptake rates for light and dark pretreated tissues may be a useful indicator of the metabolic activity of a seaweed, enabling growth patterns to be established for species in which direct measurements of growth are difficult to obtain.

J.J. BOLTON & M.A.P. JOSKA (Botany

Department, University of Cape Town, Rondebosch 7700, South Africa).

Population biology of an unusual southern African carrageenophyte: *Aeodes orbitosa* (Cryptonemiaceae, Rhodophyta).

Aeodes orbitosa is a thin, foliose red alga common in the intertidal on the west coast of southern Africa, which can reach a diameter of 2m. It contains an unusual lambda-type carrageenan which has been called 'aeodan'. Despite being common throughout the year, a 14-month study showed the species to have a clear seasonal pattern in phenology and growth. A cohort of many juveniles appeared in late winter (August); biomass and number of fertile plants peaked in summer (January); the largest plants were present in March. Sporophytes and gametophytes were present in similar numbers throughout. 'Aeodan' constituted 40-50% of dry weight in adult plants, ca. 30% in juveniles.

S.J. BRIERLEY (National Rivers Authority, Anglian Region, Aqua House, Harvey Street, Lincoln, LN1 1TF)

Eutrophication monitoring and control in lowland reservoirs.

Since the serious blooms of cyanobacteria during the summer of 1989 in many UK waterbodies there has been a renewed interest in the monitoring and control of eutrophication. The monitoring of eutrophication and several control measures will be reviewed for lowland reservoirs. Several case studies will illustrate the use of the following strategies to control excessive growths of planktonic algae: artificial mixing/de-stratification and ferric sulphate dosing for phosphorus inactivation.

J. BRODIE, M.D. GUIRY & M. MASUDA (Department of Science, Bath College of Higher Education, Bath BA2 9BN; The Martin Ryan Marine Science Institute, Galway, Ireland; Department of Botany, Hokkaido University, Sapporo, Japan)

A reassessment of *Chondrus giganteus* (Gigartinaceae, Rhodophyta) from Japan based on morphological evidence.

An investigation into the two formae of *Chondrus giganteus*, f. *giganteus* and f. *flabellatus* from Japan has revealed that they are very similar in terms of reproductive morphology. Both formae have separate unisexual gametophytes and tetrasporophytes. Carposporophyte and tetrasporophyte development both involve an

intricate interaction of vegetative and reproductive cells. Gonimoblasts in the developing carposporophyte penetrate through the medulla. Medullary cells near the auxiliary cell become enlarged and may link up with gonimoblast cells. Tetrasporangia are initiated from medullary cells as chains of tetrasporocytes which link up with other medullary cells. Carpospores and tetraspores are released through slits or pores at the soral surface. In contrast to reproductive features, both formae differ from each other in terms of gross morphology and other characters including the size and shape of medullary filaments. It is suggested that *C. giganteus* f. *flabellatus* be elevated to species status as *Chondrus flabellatus*. Further evidence in favour of this is that the two formae appear to be differently distributed, with the f. *giganteus* occurring in more southerly localities of Japan, whereas the f. *flabellatus* is found in more northerly areas. The reproductive characteristics of these two algae correspond closely with those of the type species of *Chondrus*, *C. crispus*, thus confirming the placement of both formae of *C. giganteus* in the genus *Chondrus* based on morphological features.

S.B. CALDWELL and R.O. McLEAN (Department of Biological Sciences, University of Paisley)

Shock and long-term protein induction by heavy metals in filamentous green algae.

Short term (less than 24h) exposure of *Klebsormidium*, *Stigeoclonium* and *Mougeotia* spp. to Zinc (0.1 g L^{-1}) resulted in shock protein production at molecular weights ranging from 15 - 192 KDa (demonstrated by fluorographic analysis of S^{35} labelled SDS gradient electrophoretic gels). Exposure of algae to Zn, Cu, Cd, Al, Ge and Pb over a period of three months in culture at levels ranging from 10 mg to 2 g L^{-1} depending on the metal, resulted in 'long-term protein' production at molecular weight ranges 20-30 KDa, 41-53 KDa and 150-160 KDa. The metal chelating capacities of proteins were compared using a technique of metal chelate chromatography with differing eluants (buffer, pH 6 and EDTA) distinguishing between levels of chelation.

L. CARVALHO (University of Liverpool)

Factors limiting the phytoplankton population of Rostherne Mere: past, present, and future.

Rostherne Mere, Cheshire, has one of the most important long-term phytoplankton data sets, with frequent descriptive accounts since 1912. These

accounts show that early this century nitrogen appeared to be the most important limiting factor during summer, the phytoplankton community being dominated in late summer by the nitrogen-fixing cyanobacterium *Aphanizomenon*. During the 1950s farming practices became more intensive, resulting in increased nutrient loading. *Microcystis* and *Ceratium* became the summer dominants, their populations appearing to be largely limited by light.

This present study suggests that light-limitation is still the dominant limiting factor, although nitrogen may be of slight importance during late summer. A detailed nutrient budget suggests that following recent sewage diversion, nitrogen-limitation may become important again, leading to a reversion to a phytoplankton community dominated by nitrogen-fixing cyanobacteria. Phosphorus-limitation does not look likely due to internal loading and substantial diffuse inputs from the catchment. The long-term dominance of cyanobacteria in Rostherne Mere, as in many other Cheshire Meres, therefore looks set to continue.

P.A. COURSE, G.A. TARRAN and J.C. GREEN (Plymouth Marine Laboratory, Plymouth PL1 2PB)

The life history of *Emiliania huxleyi*: Evidence for haploid and diploid states using flow cytometry.

The ubiquitous coccolithophorid *Emiliania huxleyi* exists in several forms: (a) non-motile coccolith bearing cells (C-cells), (b) non-motile naked cells (N-cells), and (c) flagellate scale-bearing cells (S-cells). It is known that C-cells can give rise to N-cells and S-cells in culture, and that occasionally C-cells can be obtained in cultures of S-cells, but the relationships between these cells are not clear. In order to estimate whether a sexual cycle is involved, experiments have been carried out to determine the relative DNA content of C- and S-cells by using flow cytometric analysis of fluorochrome-stained DNA. It has been shown that S-cells show peaks at channels 30 and 60 on a 256 channel scale, representing G1 (pre-DNA synthesis) and G2 (post-DNA synthesis/pre-mitosis) stages of the cell cycle. C-cells have peaks at channels 60 and 120. S-cells therefore contain half the DNA content of the C-cells and are haploid relative to C-cells. They may represent a gamete stage, though they themselves undergo mitosis and reproduce vegetatively. C-cells also reproduce by vegetative mitosis, but they may also be the result of gametic fusion or, possibly, the transformation of a haploid cell at the G2-(pre-mitosis) stage.

E.J. COX. (Department of Botany, The Natural History Museum, London)

Success, dominance, optima - are they measurable for natural communities of benthic microalgae?

The terms successful or dominant are often applied to the most numerous members of benthic algal communities, and optimal to the conditions under which particular species dominate communities. However, as these terms are rarely defined or related to absolute values they tend to be subjectively applied and are probably misleading.

Benthic community composition is frequently expressed as relative abundances rather than as numbers of cells of a taxon per unit area. It is therefore both affected by total species number and independent of sample density. Percentage abundance cannot provide information on species density or be used to monitor species growth (success), over time or between sites. Thus it is also inappropriate for assessing environmental optima.

Examples of the problems raised by reliance on percentage assessments will be presented. The appropriateness of applying a concept of dominance to microalgae will also be addressed.

K. DAVIDSON, A. CUNNINGHAM and K.J. FLYNN (Biological Sciences, University of Wales, Swansea; Physics and Applied Physics, University of Strathclyde)

Mathematical Modelling of Dinoflagellate Nutrient Regeneration.

We investigated the ability of a mathematical model to simulate the dynamics of the predator/prey interaction between the dinoflagellate *Oxyrrhis marina* and the photo-flagellate *Isochrysis galbana*. Two different mathematical expressions to predict nutrient regeneration from *Oxyrrhis* as a function of cellular carbon and nitrogen were examined: (i) based on the gross growth efficiency and (ii) using the concept of an optimal *Oxyrrhis* C:N ratio. The model response was compared to laboratory data and use of the second of the regeneration functions produced the more accurate simulation. The theoretical model behaviour was then examined using realistic parameter values to investigate its dynamics and the importance of nutrient cycling.

M. DAVIES**, J. GREEN* and R. DIXEY**. (*Plymouth Marine Laboratory, Citadel Hill, Plymouth PL1 2PB, UK. **Department of Medical

Electronics, St. Bartholomew's Hospital, West Smithfield, London, EC1A 7BE, UK.)

Effects of electromagnetic fields on diatom behaviour.

The marine diatom *Amphora coffeaeformis* has been reported to show an increase in calcium-dependent motility when in specific arrangements of electromagnetic fields (EMFs) which concur with theoretical models of ion stimulation. Here we report an independently produced demonstration of this phenomenon. Two of five strains of *A. coffeaeformis* tested showed susceptibility to EMFs. Using diatoms of strain III_B, log-phase cells on agar plates of varying [Ca] were exposed to EMFs for 1 hour, killed and scored for motility (recorded as presence or absence of a diatom trail in the agar). Diatoms on EMF-exposed plates consistently showed greater motility (about 20% more movers) over diatoms on sham-exposed plates (n=5 experiments, each with triplicate plates per treatment), but only when they had been grown previously for several weeks in a controlled EMF. The effect was abolished when the experimental EMF-producing coils were not energised or the frequency of the EMF was altered from its theoretical optimum. In effect we have used a diatom as a model system to demonstrate an interaction between EMF and a biological system. The consequences of this interaction for both diatom and non-phycological systems will be discussed.

J.G. DAY (Culture Collection of Algae and Protozoa, Institute of Freshwater Ecology, Windermere Laboratory).

Ex situ conservation of microalgae.

Traditionally microalgae have been maintained by routine serial subculture. Ideally cultures should be clonal, axenic, maintained under controlled nutritional and environmental regimes, and be well documented. Serial subculture has a number of disadvantages; it is relatively time consuming, potentially selective and for some strains, can not guarantee the long-term stability of morphological and physiological traits. Alternative preservation methods including drying and freeze-drying have some potential, although viability levels are low and tend to decrease on storage. Cryopreservation is the most practical method of preservation, on storage below -139°C viability levels are effectively independent of storage duration. No universal protocol is available, some strains are apparently not able to withstand cryopreservation while others have post-thaw viability levels in excess of 95%. The mechanisms of cell damage and development of

successful preservation protocols will be discussed.

G.E. DOUGLAS, D.M. JOHN & O.W. PURVIS
(Department of Botany, The Natural History
Museum, Cromwell Road, London, SW7 5BD,
UK)

**Some considerations of the lichen algal genus
Trebouxia: morphological and molecular
variation in isolates from lichens growing on
metalliferous rocks.**

Several morphologically distinct strains or "species" of *Trebouxia* were isolated from lichens growing on metalliferous rock and maintained under controlled culture conditions. Identification using light microscope discernable characteristics proved difficult, as considerable intra- and inter- culture variation was revealed in isolates from the same lichen thallus. Such morphological variation was investigated using single cell initiated cultures, removed from different areas of individual lichen thalli and significant variation was found between these cultures. These findings suggest that at the level of identification possible using characters visible using the light microscope, and based on existing keys, individual lichen thalli may contain more than one species of phycobiont. To investigate this variation further, the genetic relationship of single cell isolate cultures was examined. Restriction fragment length polymorphism patterns of 18s rRNA revealed there often to be a lack of congruence between morphological and genetic data. The results of these morphological and molecular studies will be discussed along with their implications concerning species recognition and the identification of the lichen alga *Trebouxia*. Data are also presented from studies in culture of the environmental tolerances of *Trebouxia* isolated from lichens adapted to high metal levels.

M.J. DRING (School of Biology and Biochemistry,
Queen's University, Belfast)

**Measuring growth in the field: approaches,
problems and prospects.**

Following Parke's introduction of the punch-hole technique in 1948, the growth in length of individual kelp plants in the field has often been monitored by following the movement of a marker (usually a small hole) away from the basal meristem, but it is less easy to convert this measurement into an increase in biomass for the same plant, let alone into an estimate of the

productivity per unit area of a natural population. Another group of morphologically convenient seaweeds are red or brown crusts, whose growth in area can be monitored easily, but, again, conversion into biomass increases or production per unit area of sea bed may be problematic. However, such simple methods for non-destructive growth measurement cannot be used for the majority of seaweed species, since most exhibit apical growth, with numerous apices in each plant. Direct measures of growth in length are still possible, if more laborious, than in kelps, but less direct approaches, which have been attempted only occasionally, include dimension analysis, the Allen curve technique, and extrapolation from photosynthesis measurements. This review of techniques will evaluate different approaches and attempt to stimulate renewed interest in this aspect of seaweed ecology.

R.M. FORSTER. (Biologische Anstalt Helgoland,
Postfach 180, 27483 Helgoland, and Universität
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Germany).

**UV radiation in coastal waters: spectral
measurements and effects on algal physiology.**

The role of ultraviolet radiation as a possible factor structuring sublittoral plant communities is being investigated. Tolerance of UV and/or high visible light may contribute in determining the upper limits of distribution for algae such as *Laminaria hyperborea*. Underwater light measurements were made around the island of Helgoland, southern North Sea, during Spring and Summer 1993. UV-transmission estimates from two radiometers showed good agreement. Penetration of UV radiation in the turbid waters (Jerlov type coastal 5 to 9) of this region is very low, with all UV-B (300-320nm) being rapidly absorbed in the first 2m of the water column. UV-A (320-400nm) was detectable to 5m. Test material for laboratory experiments were sporophytes of *Laminaria digitata* which had previously been cultured in UV-free conditions. Responses of photosynthetic oxygen evolution and pigment content to UV were tested by exposing plants to radiation from artificial UV light sources at realistic biologically-effective doses. A dose-response curve for inhibition of photosynthesis showed a good relationship when the UV dose was weighted by an action spectrum including both UV-A and UV-B wavelengths (chloroplast photoinhibition, Jones and Kok 1966), but not when the dose was weighted by a UV-B action spectrum

(DNA damage, Setlow 1974). This indicates that both UV-A and UV-B are important in causing loss of photosynthetic ability. The relationship between inhibition of photosynthesis and subsequent inhibition of growth was examined by measuring long-term growth rates. *L. digitata* and *L. hyperborea* sporophytes were exposed to photoinhibitory levels of UV (spectral distribution similar to that at 1-2m depth, coastal 5, clear June day) given as a supplement to white light for 12 h per day. After 5 weeks growth there was no difference in growth rate between controls (no UV) and UV-exposed plants, or between cultured plants and field material.

C.E. GIBSON, R.H. FOY and A.E. BAILEY-WATTS* Department of Agriculture, Aquatic Sciences Division, Newforge Lane, Belfast BT9 5PX, Northern Ireland, *Institute of Freshwater Ecology, Edinburgh Laboratory, Bush Estate, Penicuik EH26 OQB, Scotland)

Phosphorus and chlorophyll: effect of enrichment on the annual cycle.

In general, enrichment of lakes with phosphorus (P) produces larger crops of planktonic algae, but what happens to the annual cycle? Does a greater P loading lead to a general increase in concentration, or an increase in the maximum with a greater annual range? Data from a range of UK lakes are analysed according to a simple model which envisages the annual total P (TP) concentration varying sinusoidally. The data show that as the annual maximum TP level increases so does the annual range; in other words, the amplitude of the wave increases. Some implications of this finding are discussed for sampling strategies and interpreting synoptic surveys. The relationship between annual TP cycles and chlorophyll *a* is also explored.

C.M. HAPPEY-WOOD (School of Biological Sciences, University of Wales, Bangor).

Growth of phytoplankton: allusive, inaccurate or just impossible to assess?

Algal growth is the culmination of the photosynthetic process. Initially growth is expressed as increased cell-carbon, storage products and/or cell-size. Ultimately under favourable conditions of light and nutrients cell division and an increase in total planktonic cell numbers ensues. Growth may be studied in a variety of ways from the molecular to the cellular level. Methods include measurements

of rates of cell metabolism or primary production, levels of cell components to finally numbers of cells or colonies. In cultures these approaches are of definable accuracy and precision. However in natural phytoplankton populations the scenario is far from simple, and determinations of phytoplankton growth involve understanding not only of the algae and their growth requirements but additionally loss processes such as grazing, sedimentation and outflows. The extent to which we can estimate phytoplankton growth in natural populations will be discussed.

C.M. HAPPEY-WOOD, C. BURGESS-WAHL and S. GASKIN. (School of Biological Sciences, University of Wales, Bangor).

Environmental problems in freshwater habitats: impact on the picoplankton community.

Current environmental problems include acid deposition and increased ultraviolet radiation. In aquatic habitats little attention has been paid to these potentially deleterious environmental changes on microscopic algae and their fundamental role in the microbial food web. Acid deposition in North Wales, an area of the U.K. sensitive to increased acidity will be addressed. Firstly, experimental work on the effects of catchment-liming to ameliorate extreme acidity in Llynau Gamallt will be discussed. Secondly, experimental manipulation to increase acidity in lakes of contrasting trophic status will be described. Finally in the context of potential increase in ultraviolet radiation, experiments studying the effects of U.V. on phyto- and picoplankton community production will be presented.

It is evident that within planktonic communities considerable physiological flexibility exists to enable acclimation of microbial production and thus survival in continually changing environmental circumstances.

A.S.D. HARRIS^{***}, L.K. MEDLIN **, J.M. LEWIS* and K.J. JONES^{***} (*University of Westminster, London, **Alfred Wegener Institute, Bremerhaven and ***Dunstaffnage Marine Laboratory, Oban)

***Thalassiosira* species (Bacillariophyceae) from a Scottish sea-loch.**

During the spring diatom blooms of 1992 and 1993 in Loch Creran regular water column and sediment samples were collected, examined and species composition of the phytoplankton determined. Species from the genus *Thalassiosira*

were found to be a major constituent of the blooms. The identification of species was determined on specimens, cultured from sediments and isolated from vertical net hauls, using light and scanning electron microscopy.

Of the 18 species positively distinguished, only *Thalassiosira angulata*, *T. anguste-lineata*, *T. eccentrica*, *T. gravis*, *T. minima*, *T. nordenskiöldii*, *T. rotula* and *T. tenera* have been previously reported in Scottish waters. Other species, including *Thalassiosira pseudonana* and *T. punctigera* have been noted elsewhere in the British Isles but not along the Scottish west coast. Further species, including *Thalassiosira concavuscula*, *T. constricta*, *T. delicatula*, *T. hispida*, *T. kuschirensis*, *T. oceanica* and *T. pacifica* are new records for the British Isles. A species previously unrecorded in north eastern Atlantic waters was *T. tealata* and a taxonomic description is provided.

C.R. HEATH, B.S.C. LEADBEATER and MAUREEN E. CALLOW (School of Biological Sciences, University of Birmingham)

Precipitation of calcium carbonate by freshwater algae.

Algae representative of all phyla can precipitate inorganic salts, the majority of deposits being calcium carbonate. In laboratory tests, 13 species of freshwater algae have been shown to precipitate CaCO_3 from an artificial hardwater medium. The deposition of salts will be discussed in relation to algal morphology and inorganic carbon utilization. In all cases, photosynthesis played a major role and it is suggested that if a water is highly saturated with respect to CaCO_3 , all submerged photosynthesizing organisms may become encrusted with crystals.

An algal culture system will be described in which changes in parameters such as conductivity, pH, soluble calcium, ionic strength, saturation index and PCO_2 can be continuously monitored throughout the precipitation reaction, thus allowing calculation of crystal growth rates. The potential use of this method for investigating the mechanisms involved in the deposition of CaCO_3 mediated by algae will be discussed.

B.R. HITCHINGS, B.W. FERRY and T.W. FORD. (Royal Holloway, University of London).

An ecophysiological study of *Scenedesmus* isolates from water bodies at Dungeness, Kent.

Field work was carried out on phytoplankton populations from Dungeness, Kent, and the data

was analysed using various community analysis statistical packages. Being a coastal site, salinity was shown to be an important factor for these, essentially fresh water, algal populations. Several species were isolated from Dungeness field samples and subjected to batch culture salt tolerance tests. Of particular interest was the genus *Scenedesmus*, as not only did it show higher salt tolerance in laboratory culture than in the field, but several morphological changes were seen to occur under such conditions. Morphological variability showed some correlation with reduced growth rates, suggesting that these morphological changes are the result of internal physiological processes. When grown in mixed culture, however, salt tolerance was reduced, and this was seen to a greater extent when experiments were moved from batch into continuous culture. Salt tolerance and polymorphism showed inter and intraspecific variations, though it could be argued that polymorphism is largely a laboratory induced situation, as only one example of polymorphism was seen during a year of field data collection.

R. HUXLEY, I. TITTLE and W.F. FARNHAM* (The Natural History Museum and *University of Portsmouth)

Disturbance effects of an oil terminal on the marine algae of Sullom Voe, Shetland.

Sullom Voe is a long, relatively sheltered inlet of the North Sea and the site of Europe's largest oil terminal. A first appraisal of the marine algae of the Voe was undertaken in 1973 prior to oil terminal construction. Distinct algal assemblages were recorded at wave-exposed outer Voe sites and sheltered inner Voe sites and these varied with depth and substrate. In the Outer Voe *Laminaria hyperborea* forests characterised the subtidal algal communities while in the inner Voe *L. saccharina* was the dominant species. Underflora species assemblages also varied according to depth and substrate. Where sand and silt predominated, assemblages of either free-living plants or plants on small stones and shells were characterised by various filiform brown algae (in shallow waters), *Phyllophora crispa* and *Audouinella floridula* (in deeper waters). Reappraisal in 1983 revealed disturbance effects in the vicinity of the oil terminal where there had been considerable engineering works. *L. hyperborea* was not relocated. Other habitats and communities appeared stable. Further reappraisal in 1993 suggested a return to the 1973 situation at the disturbed sites and stability elsewhere.

P.M.A. JAYASURIYA, and J.M. KAIN (Jones). (Port Erin Marine Laboratory, University of Liverpool.)

Harvesting experiments on three important seaweeds in Sri Lanka.

Experimental clearances were made within quadrats of *Sargassum wightii*, *Gracilaria corticata* and *Gelidium* sp. along the west coast of Sri Lanka to determine the best harvesting method and the time taken for regeneration of each species.

Cut or scraped *S. wightii* plants with the holdfasts remaining gained the original biomass in about 5 months during the early months of the year while it took about 6 months during the latter half of the year. Cut or scraped *Gracilaria corticata* plants with the holdfasts remaining recovered the original biomass within 4 months. *Gelidium* plants showed the slowest regrowth by taking almost 10 months to recover when plants were cut and more than 10 months to recover when the rock was scraped.

D.M. JOHN (Department of Botany, The Natural History Museum, London, UK)

The link between conservation, biodiversity and eutrophication.

Understanding the structure and functioning of aquatic communities relies on an adequate knowledge of the diversity of genomes, organisms, communities and ecosystems. Knowledge of biodiversity patterns along with its creation, maintenance and regulation remains woefully inadequate and yet it provides the essential scientific underpinning necessary for predicting the role of human-mediated and natural processes in community change. Considered are examples of the often profound and generally undesirable changes in biodiversity caused by elevated nutrient levels. Concern to conserve natural or semi-natural systems in the face of threats from human activities has led to national and global initiatives to improve our knowledge of biodiversity. Some of these biodiversity initiatives are discussed in the context of our inability to often provide to policy makers the information needed to make decisions concerning the conservation and management of aquatic organisms and their habitats.

A.M. JOHNSTON and J.A. RAVEN. (Department of Biological Sciences, University of Dundee DD1 4HN)

The use of natural abundance $^{13}\text{C}/^{12}\text{C}$ ratios in

the study of inorganic carbon acquisition by *Phaeodactylum tricorutum*.

The natural abundance of the stable isotopes of carbon (^{13}C and ^{12}C) and the terminology of their use are introduced. The biological and physical processes which can influence the ^{13}C ratio of organic carbon are reviewed. This study shows that when grown under light and inorganic carbon saturation the marine diatom *Phaeodactylum tricorutum* has a ^{13}C value of -23.6% . This value is less negative than expected if the carbon fixation process was based solely on RUBISCO and CO_2 diffusion. This maybe due to inorganic carbon accumulation or an increased CO_2 diffusion resistance. Changes in the photosynthetic physiology of *Phaeodactylum tricorutum* in response to changes in the CO_2 concentration used for growth indicate that this alga is able to increase its ability to accumulate inorganic carbon. This is reflected in less negative ^{13}C values at lower than air-equilibrium CO_2 concentrations. Differences in growth CO_2 concentration, between 5.5 and 65 Pa CO_2 , did not affect the growth rate of this diatom. The effect of temperature and PFD on the ^{13}C value is also discussed. It is concluded that $\delta^{13}\text{C}$ data can have an important role as an indicator of the growth conditions for the laboratory culture of marine phytoplankton.

J.I. JONES, J.W. EATON and K. HARDWICK (University of Liverpool, UK.)

Interactions between submerged aquatic plants and epiphytic algae- microelectrode investigations of boundary layers.

It has been suggested that a nutrient-mediated increase in epiphytic algae is the cause of the loss of submerged plants which is often associated with eutrophication, though no causal mechanisms for such a loss have been established. In the case of slow growing, isoetid plants which have leaves in a basal rosette and can take up carbon dioxide through their roots, the effect may be the result of shading. In elodeid plants, which have a very rapid growing, caulescent growth form and take up dissolved gases from the surrounding water, the mechanism of algae interference is less clear, with both shading and the disruption of gas exchange being suggested. A pH microelectrode apparatus (tip diameter $5\ \mu\text{m}$, sensitivity 0.01 pH) has been developed to probe the microenvironment (within 2.5mm of the leaf surface) surrounding the leaves of clean and epiphytised *Elodea nuttallii*, a plant typical of eutrophic waters. The results of an investigation into the interference to carbon dioxide

exchange caused by a layer of epiphytic algae on the leaf surface will be presented.

J.M. KAIN (Jones) (Port Erin Marine Laboratory, University of Liverpool)

Confusing *Delesseria* with short and long days.

Gametophytes of *Delesseria sanguinea* require a night length of 12 hours or more for the stimulation of the formation of reproductive structures. It is not necessary, however, for every night to be long; with as few as 3 long nights per week both males and females eventually become fertile. This is in keeping with the observation that triggering in the sea takes place before the equinox: underwater daylength can be quite variable because of the differing timing of low water. In a mixture of night lengths male bladelets show some characteristics of new blades (which normally develop after reproduction has taken place) in that they grow to a larger size and are more deeply pigmented than the bladelets in continuous short days. Male plants removed from long nights more than three days before they produce spermatangia halt the progression to fertility, remain sterile, become pink and may continue growth. In contrast to the gametophytes, tetrasporophytes subjected to mixtures of night lengths may develop reproductive bladelets or may produce new blades but many outgrowths remain small in an 'undecided' state.

D.W. KEATS and Y.M. CHAMBERLAIN (Botany Department, University of the Western Cape, South Africa. The Marine Laboratory, University of Portsmouth, England)

***Heydrichia globularis* sp. nov.: a new species of crustose coralline alga (Rhodophyta, Corallinales) from western Cape Province, South Africa.**

Heydrichia globularis sp. nov., the second recorded species of this recently-described genus, is described from western Cape Province, South Africa and southern Namibia. It is ascribed to the genus *Heydrichia* on the basis of a type of sporangial development which results in multiple sporangial stalk cells, as well as asymmetrically enlarged pit-plug caps. It is distinct from *A. woelkerlingii* Townsend, Chamberlain & Keats on the basis of a much thinner thallus, broader thallus cells, and smaller tetrasporangia and tetrasporangial chambers. In addition, *H. globularis* appears to have a broader distribution in southern Africa than does *A. woelkerlingii*.

G.M. KENNAWAY, J.D. DODGE and J. LEWIS* (Royal Holloway and Bedford New College, University of London and *Westminster University, London).

The temporal and spatial distribution of phytoplankton in the Irish Sea during May 1993.

A model of the Irish Sea distinguishes four hydrodynamic regions; the seasonal summer stratified and frontal regions and the coastal and mixed regions. From a mooring deployed in the stratified regions water were taken from the chlorophyll fluorescence maximum or 17.0 metres every two to three days and preserved in Lugol's iodine (1.0%). In early May when chlorophyll concentrations were relatively high (7.9 mg/m³) diatoms (1784 cells/ml) and nanoflagellates (575 cells/ml) dominated the phytoplankton. In the stratified region storm events prevailing at the time contributed to fluctuations in biomass and floristic composition of the phytoplankton over time intervals of less than twenty four hours. Between May 21-23rd physical conditions caused chlorophyll concentrations to fluctuate between 4-12 mg chl/m³ with the advection or resuspension of diatoms and phytoflagellate numbers to increase from 100-2900 cells/ml. The implications of these short-term events will be discussed in relation to our understanding of species succession and the floristic composition of blooms.

S. KILINC (Department of Environmental and Evolutionary Biology, University of Liverpool)

Phytoplankton communities in the West Midland meres.

Phytoplankton community compositions and environmental variables were examined in nineteen of the West Midland meres from July 1991 to June 1992.

Data were evaluated by a multivariate analysis called Canonical Correspondence Analysis (CANOCO), to examine the effects of environmental variables on the phytoplankton communities. Neither chlorophyll *a* concentrations nor the phytoplankton community was closely correlated with environmental variables over the whole group of lakes. However, when the lakes were separated into shallow (< 3m. max.) and deep (> 3m. max.) sub-groups, patterns emerged within each group. The phytoplankton community was related to nutrients in shallow lakes with total phosphorus, soluble reactive phosphorus and, pH the most significant environmental variables. Zooplankton numbers (especially *Daphnia* spp.) proved important also in the shallow lakes. In the

deep group, Ammonium nitrogen was an important determinant variable of community composition, as was total inorganic nitrogen of chlorophyll *a* concentration. t-tests showed no significant differences between the biomass of algal divisions between deep and shallow groups.

R. KINSMAN, A.E. WALSBY and P.K. HAYES (School of Biological Sciences, University of Bristol).

Investigating the interaction between GvpA and GvpC.

Gas vesicles isolated from *Anabaena flos-aquae* contain two types of protein: GvpA (Mr 7397), a hydrophobic protein, and GvpC (Mr 21985). GvpC is located on the outer surface of the gas vesicle; its function is to strengthen the gas vesicle. Native GvpC is comprised of 18 amino acids at the N-terminus followed by 5 contiguous repeats of a 33 amino acid sequence and 10 amino acids to the C-terminus: It is suggested that each of the 5 GvpC repeats binds to 5 molecules of GvpA, forming ties between adjacent ribs in the gas vesicle. In order to investigate the way in which the GvpC repeats bind and the way in which they might have evolved we have prepared a series of modified GvpC proteins that contain 1, 2, 3 or 4 of the internal 33 amino acid repeats; we will describe the strategy used to produce these modified proteins. The interaction between the modified GvpC proteins and gas vesicles stripped of their native GvpC will be discussed.

J.E. KÜBLER & J.A. RAVEN (Department of Biological Sciences, University of Dundee, Dundee DD1 4HN)

Consequences of light-limitation for inorganic carbon uptake in red seaweeds.

We investigated the consequences of growth under variable photon flux densities for inorganic carbon uptake in two species of red seaweed which possess an inorganic carbon concentrating mechanism (*Palmaria palmata* and *Laurencia pinnatifida*) and one species which is dependent on diffusive uptake of CO₂ (*Lomentaria articulata*). We found that light-limitation of growth was correlated with more negative values of $\delta^{13}\text{C}$ (relative to PDB) and lower initial slopes of DIC uptake response curves in *P. palmata* and *L. pinnatifida* but not in *L. articulata*. The indication that light limitation is associated with decreased efficiency of carbon use in *P. palmata* and *L. pinnatifida* is further supported by the occurrence of decreased C : N

ratio, total carbon content, and % dry weight in those species but not in *L. articulata*, although all three species show evidence of photoacclimation. These results are discussed in terms of the potential energetic tradeoffs between active carbon uptake and photolimitation.

K. LÜNING (Biologische Anstalt Helgoland, Zentrale Hamburg)

When do algae grow? Circadian and circannual growth rhythms in seaweeds.

Do seaweeds grow more during the day than at night? How does their short-term growth rate kinetics look like, if one could monitor growth rate from hour to hour? Do seaweeds grow at a constant rate in continuous light or dark? Historical pioneer work is addressed which tried to approach these questions, more for unicellular algae than for seaweeds in the past. Recent work based on computer-assisted image analysis revealed the fine structure of short-term growth kinetics in green, brown and red seaweeds. Circadian growth rhythms were detected in several seaweed species, and much of the characteristic day/night patterns of growth rate can be explained by circadian growth rhythms being synchronized by light/dark cycles. Other questions relate to the long-term aspect. In experiments conducted over months and years - do seaweeds grow continuously in constant daylengths? How do seaweeds control their seasonal growth behaviour? Pioneer work is presented also in these respects. Recent results from long-term growth experiments in seawater tanks exhibited that the seasonal rhythms of growth in several seaweed species are endogenously produced by a circannual clock, as in many other organisms, from unicellular algae to mammals.

G. MANEVELDT and D.W. KEATS (Botany Department, University of the Western Cape, South Africa).

***Leptophytum foveatum* Chamberlain & Keats (Rhodophyta, Corallinales) retaliates against competitive overgrowth by other encrusting algae.**

The encrusting coralline alga, *Leptophytum foveatum*, is the most abundant crustose alga in the lower eulittoral zone at Yzerfontein and other exposed sites on the West Coast of South Africa. The surface of this species is usually imbricate (appears scaly) as a result of the apparently spontaneous regeneration of margins at the surface

of the thallus. The thicker, fleshy, brown crustose alga, *Ralfsia verrucosa*, usually overgrows the margins of the thinner *L. foveatum*; however, *L. foveatum* counteracts this overgrowth by regenerating margins at the thallus surface, and these are able to grow up and over the encroaching margin of *R. verrucosa*. Experiments in which these regenerated margins were removed showed that the regenerated margins are able to slow or stop the encroachment of *R. verrucosa*. It is suggested that the regeneration of thallus margins at the surface, away from the primary thallus margin, allows *L. foveatum* to maintain the advantages of being thin (eg. more rapid lateral growth), but also gain some of the advantages of being thick (eg. improved competitive ability).

C.A. MAGGS and B.A. WARD (School of Biology & Biochemistry, Queen's University, Belfast).

Alien seaweeds?

Recognition of introduced marine algae may be difficult, and a species has sometimes been described as new in each region to which it has been introduced. The converse can occur, so that related species with disjunct distributions are erroneously considered to represent a single species introduced into different geographical areas. We are investigating the relationship between alien populations and their potential source populations by plastid DNA analysis and conventional methods. This will provide information crucial to establishing the correct names of introduced species, required for Schedule 9 of the Wildlife and Countryside Act, under which transport of certain named seaweeds is restricted.

Antithamnion densum (type locality: Peru) was found in Ireland at two offshore islands. At present, this species is believed to occur widely in the North and South Pacific, known under names such as *A. sparsum* and *A. defectum*, and French populations are thought to be introduced. However, our Irish isolate is not interfertile with *A. sparsum* from Korea, which is polyploid compared to Irish *A. defectum*. Their plastid DNA banding patterns show about 50% similarity, suggesting that they are a pair of closely related species or geographically isolated subspecies. Molecular, morphological and breeding data indicate that *A. densum* is not a recent introduction, but a native North Atlantic species.

In contrast, our results for *Antithamnionella spirographidis*, described from the Mediterranean in 1916 and first reported from England in 1934, confirm recent suggestions that it is of North Pacific

origin. Several British isolates are interfertile with Californian "*A. glandulifera*"; plastid DNA banding patterns of isolates from Hampshire and California are almost identical.

S. McGOWAN (Departments of Environmental and Evolutionary Biology/ Biochemistry, University of Liverpool, and IFE, Windermere)

Blue-green algal blooms: a pristine feature of the Shropshire meres?

The Shropshire meres have a long history of algal blooms, dating back at least into the last century. The 'breaking of the meres', as the phenomenon is known, is a well established part of the folklore of the area. The meres are also thought to be naturally eutrophic.

Reconstruction of past algal communities has been attempted in White Mere (near Ellermere), using palaeolimnological techniques. High Pressure Liquid Chromatography (HPLC) was used to separate fossil carotenoids in the lake sediments. An assemblage of carotenoids characteristic of prokaryotes was plentiful, even in immediately post-glacial sediments. This may suggest that blooms are a long-term natural feature of the lake rather than symptoms of anthropogenic influence.

B.J. MCGREGOR and R.I. LEWIS (Port Erin Marine Lab, University of Liverpool, School of Biological Sciences, University College of Swansea, Singleton Park, Swansea SA2 8PP Wales)

A morphological and biochemical genetic investigation into British *Porphyra* species.

Species in the genus *Porphyra* are notoriously variable in form. Morphology is known to vary dramatically across environmental gradients such as shore height and exposure grades. Field identification of *Porphyra* species is further complicated by an absence of conspicuous distinguishing features, since *Porphyra* species are relatively simple in gross structure. The potential for taxonomic confusion, therefore, is great.

In the present study field identification of species and forms was undertaken on the basis of traditional morphological criteria. Individual plants assigned to specific morphological groups were then investigated using biochemical genetic techniques. Plants were scored at twelve allozyme loci, eleven of which were usefully polymorphic. Genetic data were subsequently examined independently of morphological groupings. Specific assignments for both morphological and biochemical criteria were found to be concurrent for all but the group

assigned on morphological grounds to the species *Porphyra laciniata*. Biochemical genetic data showed strong evidence for two distinct species in this group. *A. posteriori* investigation revealed clear structural distinctions and discernable ecological partitioning between the two species.

R. MITCHELL (English Nature, Peterborough)
Marine macro-algae: protection and introduction control.

British marine macro-algae are considered in relation to current nature conservation principles and policies for the protection of species and their habitats and the control of non-native introductions. The context of national legislation (eg Wildlife and Countryside Act, 1981), EC Directives (eg Habitats and Species Directive) and international conventions (eg Biodiversity Convention) is examined.

Knowledge of the distribution, autecology and threats to British marine algae does not match that for terrestrial plants. What more do we need to know to evaluate conservation requirements and design effective conservation strategies? How do we decide which algal species are rare and endangered? For example, are those species which are confined to restricted and diminishing coastal habitats (eg chalk cliffs and saline lagoons) in need of an action plan for their recovery. In any case, how appropriate are species protection and enhancement programmes which were developed largely to meet terrestrial requirements? Why should nature conservationists be concerned about the introduction and establishment of non-native marine algae? Answers are both offered and sought to these and other questions posed.

B. MOSS, P. JOHNES and G. PHILIPS*
(Department of Environmental and Evolutionary Biology, University of Liverpool, Liverpool L69 3BX and *NRA, Eastern Region)
Conservation and the assessment of eutrophication.

The British government is required to define waters which are eutrophicated or likely to become so, under the terms of the Urban Waste Water Directive. The DOE has made proposals based on criteria derived from a report by the OECD (1982) but considerable problems attach to these criteria. The present philosophy of assessing quality of freshwaters by such fixed criteria (Spatial State Schemes) is questioned and the advantages of Value Changed Schemes are examined. Results from the application of such a scheme are given and suggest

a much greater incidence of eutrophication of British freshwaters than is likely to be detected by use of the proposed DOE criteria.

J.H.T. O'MAHONY. (Department of the Marine, Fisheries Research Centre, Abbotstown, Dublin 15, Ireland.)

Shellfish Transfers within the EC - Implications for phytoplankton and other species.

Prior to January 1993, importations of shellfish into Ireland were strictly controlled. The implementation of EC Council Directive 91/67/EEC now permits the free movement of shellfish within the European Community. In January 1993, imports of the Pacific oyster *Crassostrea gigas* were examined for the presence of phytoplankton benthic microalgae and other microspecies. Sixty-five species of microalgae (43 diatoms, 20 dinoflagellates (19 dinoflagellate cysts), 2 silicoflagellates) were recorded, in addition to other species such as foraminiferans and tintinnids. Other exotic invertebrate animals were also recorded in a parallel survey. There is concern that accidental importations of exotic and/or potentially harmful phytoplankton species with shellfish transfers may have negative implications not only for public health and aquaculture, but also for the ecology of native flora and fauna.

G. PEARSON and I.R. DAVISON. (Dept. Plant Biology, University of Maine, Orono, ME 04469, USA).

Freezing and Hyperosmotic Stress in *Fucus distichus*: Evidence for Physiological Similarities.

The effects of osmotic dehydration and freezing on photosynthesis were studied in the tide pool brown alga *Fucus distichus* L. Both stresses inhibited light-limited (P_{submax}) and light-saturated (P_{max}) photosynthesis measured immediately after plants were re-immersed in seawater. The degree of initial inhibition and subsequent recovery of photosynthesis were proportional to the severity of the dehydration or freezing treatment. P_{submax} and P_{max} recovered completely from osmotic dehydration for 3 h in 200‰ and freezing for 3 h at -10°C , but recovery was only partial following 3 h in 300‰ or 3 h at -15°C . In most cases, recovery was complete within 2 h following dehydration or freezing, with little further recovery occurring between 2 and 24 h post-treatment; results similar to those reported in the literature for desiccation in air. Observations using the vital dye

fluorescein diacetate suggested that the lack of complete recovery might be due to severe damage or death of a proportion of the cells in the thallus. It was shown in further experiments that osmoacclimation in hyperosmotic seawater (51‰) for 14 days increased the ability of *F. distichus* to recover from freezing at -15°C. This was not directly linked to increases in cellular mannitol concentration (a compatible solute in brown algae), but was accompanied by changes in the behaviour of the plasma membrane. Based on these data we suggest that there are common cellular and physiological components involved in the response of furoid algae to a range of water stresses.

D.G. RAFFAELLI. (Culterly Field Station, University of Aberdeen).

Macro-algal blooming in the Ythan Estuary, Scotland, and its ecological effects.

Mats of opportunistic green algae (*Enteromorpha*, *Ulva* and *Chaetomorpha*) cover extensive areas of the intertidal mudflats in the Ythan Estuary. At high weed biomasses there are dramatic effects on the invertebrate assemblages underlying the mats, especially on populations of the amphipod *Corophium volutator* which is the main prey of most of the predators in the food web. Field experiments demonstrate that invertebrates may be affected by both the physical presence of the weed as well as a deteriorating chemical environment. Analyses of long-term data sets on weed mats, invertebrates and shorebirds reveal trends in these parameters consistent with increases in nutrients in river water and changes in land-use in the catchment.

J.A. RAVEN, A.M. JOHNSTON, J. KÜBLER and R. PARSONS (Department of Biological Sciences, University of Dundee, Dundee DD1 4HN, UK).

The influence of high oxygen concentrations in algae.

The extent of O₂ build-up within photosynthesing algal cells is substantial relative to the medium if an inorganic C concentrating mechanism operates or if diffusive CO₂ entry occurs with a high external CO₂ concentration. Large build-ups of O₂ in nature depend on high rates of net photosynthetic production in an aqueous medium relative to the rate of O₂ loss to the atmosphere; O₂ concentrations within the cells of algae can be 3 or more times air-equilibrium.

The impact of these high O₂ levels on photosynthesis and growth involves both photosynthetic effects related to competition with CO₂ in RUBISCO activity, and increased rates of generation of toxic O species. Photosynthesis in most algae involves CO₂ concentrating mechanisms, and O₂ does not greatly inhibit photosynthesis in these plants. The growth of algae at high O₂ concentrations has been less frequently investigated, but it is usually not inhibited until external O₂ concentration exceeds three or four times air-equilibrium; certain mutants are even more tolerant. The level of enzymes which detoxify the toxic O species is generally higher in algae acclimated to high O₂, as well as in the O₂ tolerant mutants relative to wild-type. Since the growth rate is not decreased at high O₂ the resource diversion to increased detoxification potential of toxic O species does not decrease the potential for growth.

P.K. ROBINSON (Department of Applied Biology, University of Central Lancashire, Preston, PR1 2HE, UK.)

Phosphate uptake kinetics of free and immobilized microalgae.

Study has been made of the uptake of orthophosphate (PO₄-P) by *Chlorella emersonii* (CCAP 211/8a) in batch culture and in immobilized systems involving gel entrapment (alginate and agarose) and hollow-fibre reactors. Algae grown in batch culture to stationary phase and then placed in fresh growth medium (containing ≈100 μM P) removed P rapidly. Removal followed exponential kinetics. Cells removed half of the available phosphate from the medium each 0.9h (i.e. t-half=0.9h). Surprisingly, results show that such cells were not P-limited; nor does P-starvation result in an enhancement of P-uptake ability. Gel-entrapped cells were less effective in P-uptake, with t-half values of 2.7h. Studies involving packed-bed reactors containing gel-entrapped algae reveal that alginate-entrapped systems could be operated for 12d and displayed average removal efficiencies of 40-70%, whilst agarose-entrapped systems have been shown to be physically more stable and have been operated for periods of up to 70d. Hollow-fibre reactors offer advantages in that they display near total physical stability, and allow cell replacement. Preliminary studies, however, show that cells in such reactors suffer from severe mass transfer limitation unless the cell suspension on the shell side of the fibres is recycled.

D.J. ROGERS, A.H. SAMPAIO*, C.J. BARWELL, W. GERWICK** and M. WISE** (School of Pharmacy & Biomedical Sciences, University of Portsmouth, England, *Department of Biochemistry and Molecular Biology, Federal University of Ceara-Brazil, CNPQ, **College of Pharmacy, Oregon State University, Corvallis, Oregon, USA).

Characterisation of the galactose-binding lectins from *Ptilota filicina*, purified by affinity chromatography on guar gum gel.

Ptilota plumosa and *P. serrata* are known to contain lectins which bind α -D-galactose and require the presence of divalent cations in order to function as haemagglutinins. In another important respect the lectins are different as the *P. plumosa* lectin is blood-group B specific, whereas the *P. serrata* lectin is not. As part of a programme to determine the molecular basis for this difference we have purified and characterised a lectin from *P. filicina*.

P. filicina, 200 g, from Oregon, USA was extracted with 200 ml phosphate, buffered saline (0.17 M pH 7.3). Proteins in the extract were precipitated by 75% saturation with ammonium sulphate, applied to a column of cross-linked guar gum gel, eluted with 0.1 M galactose, dialysed against 0.25 M acetic acid and concentrated by filtration.

The 1.2 mg of lectin obtained was subjected to SDS polyacrylamide gel electrophoresis to assess purity. Studies of the purified lectin showed it to be a galactose-binding molecule, having a divalent cation requirement, but no specificity for blood-group B.

G. RUSSELL. (Department of Environmental & Evolutionary Biology, The University of Liverpool).

A Baltic ecotype of *Pilayella littoralis* Agg.

Cultured isolates of *P. littoralis* from U.K. and S.W. Finland grew with similar vigour. Optimum growth of the U.K. clone was obtained at 34 ppt. but growth occurred over a salinity range of 6-45 ppt. The Baltic clone grew in media of 1.5-45 ppt., with 6 ppt. best.

Main filament thickness proved a fairly stable character in U.K. cultures but was somewhat plastic in Baltic material. Nevertheless the Baltic ecotype is distinguishable morphologically in having mean thicknesses of main filaments and sporangia less than 30 μ m. Observations on natural populations suggest that

the geographical limit of "*P. baltica*" lies in the vicinity of Copenhagen.

A.H. SAMPAIO and D.J. ROGERS (Department of Biochemistry and Molecular Biology, Federal University of Ceara, Brazil-CNPq. School of Pharmacy & Biomedical Sciences, University of Portsmouth, England).

Purification of galactose-binding marine algal lectins on guar gum gel.

Galactose-binding algal lectins have previously been purified by affinity chromatography using a specific simple sugar (ligand) bound to an insoluble matrix (resin). There are some problems associated with this process, however, as large volumes of sugar eluant are required and the preparation of the affinity resin is time consuming and expensive.

Cross-linked guar gum, a galacto-mannan consisting of chains of β -D-mannose with α -D-galactose linked (1-6) as single unit side chains, has been used as an efficient, inexpensive and rapid general affinity medium for the purification of galactose-binding lectins from higher plants. In this communication we describe the use of this method for the isolation of the galactose-binding lectin from the red marine alga *Ptilota serrata*.

Proteins in phosphate-buffered saline (0.17 M, pH 7.3) extract of freeze dried alga were precipitated by 75% saturation with ammonium sulphate and applied to a column of guar gum gel. Lectins were eluted from the column with 0.1 M galactose, dialysed against 0.25 M acetic acid and concentrated by filtration. The yield of 1.02 mg of lectin from 30g of freeze-dried alga compares favourably with other more complex and expensive affinity chromatographic methods.

R. SCHMID and M. J. DRING (School of Biology and Biochemistry, Queen's University, Belfast)

Role of blue light in carbon acquisition by *Laminaria saccharina*.

Photosynthetic rates of *Laminaria saccharina* under saturating red light can be increased by continuous blue light. Short pulses of blue light cause transient stimulations with lag phases of about 2 min and maximum rates after about 10 min. Earlier studies had suggested that the effect of blue light was connected with the availability of dissolved inorganic carbon (DIC) for photosynthesis since the affinity for carbon was

changed in the presence of blue light (Forster and DRING 1992, *Plant Cell Environ.* 15, 241-247). This hypothesis has been analysed in more detail. In pH drift experiments, the pH-compensation points were higher in the presence of blue light than in red light alone. Lowering the pH of the seawater increased overall photosynthesis but the blue light response was lost. At pH 8.5, blue light stimulated photosynthetic rates at DIC-concentrations of up to 10 mM, whereas no significant stimulation was seen at pH 6.5. The response to blue light was decreased in buffered seawater and it was almost completely suppressed by inhibitors of carbonic anhydrases. Active carbonic anhydrase is clearly necessary for the blue light effect, and we suggest that the external pH-shifts, which are also induced by blue light (Schmid and Dring 1993, *Plant Physiol* 101, 907-913), are required to maintain appropriate pH conditions for the activity of external carbonic anhydrase in the apoplast.

E. SERRÃO^{*,**}, L. KAUTSKY^{***}, and S.H. BRAWLEY^{*} (^{*}Dept. Plant Biology, Univ. of Maine, Orono, ME 04469, USA, ^{**}U.C.T.R.A., Univ. Algarve, 8000 Faro, Portugal, ^{***} Dept. Botany, Stockholm Univ., S-10691 Stockholm, Sweden).

Fertilization ecology of *Fucus vesiculosus* in the Baltic Sea.

Fucus vesiculosus is the dominant marine seaweed in the Baltic Sea. In this habitat, where a decrease in salinity has been occurring from ca. 3000 years ago, *F. vesiculosus* is still reproductive at salinities as low as 4‰. In lower salinity habitats, polyspermy may be high, since these algae have a fast-block against polyspermy which is Na⁺-dependent. Low salinities may also reduce sperm motility. Fertilization success and polyspermy levels were determined for *F. vesiculosus* at Askö (6.5‰, Baltic Sea), using aceto-iron-hematoxylin stain on eggs/zygotes collected on artificial substrates in the field. Fertilization success was high and polyspermy low. These samples were collected at times of high gamete release, which were determined by monitoring egg settlement on artificial substrates and gamete release from receptacles kept in test tubes in the field or in a culture chamber. The release of eggs and sperm was synchronous. The motility of sperm from two localities in the Baltic Sea (4.1‰, and 6.5‰), and two fully marine localities (Swedish west coast, approx 30‰ and Iceland, 32‰), was recorded by video and

compared over salinities from 3‰ to 32‰. Motility of marine sperm was best at 32‰, and mostly zero at 6‰. Motility of Baltic sperm was best at 15‰, but still good at 6‰, and a small proportion still swim slowly at 4‰. Pronuclear migration in Baltic zygotes (13°C) was slower than for marine fucoids. Fertilization between Askö gametes (1000: 1 sperm:egg), assessed with calcofluor white, was more successful at and above 6‰ and very reduced at 4‰ and 3‰, which may be related to the swimming ability of the sperm. In summary, Baltic populations of *F. vesiculosus* have adapted to their low salinity habitats, but not fully, as their gametes perform better at salinities that are higher than those in which adults are found. Reductions in sperm motility may be an important factor in setting the northern limit of the species in the Baltic Sea. [Supported by the Natl. Geographic Soc. and NSF (S.H.B.), Fulbright and JNICT, Portugal (E.S.), and the Swedish NRC (L.K.).]

L.E. SHUBERT. (Department of Biology, University of North Dakota, Grand Forks, ND 58202 USA)

Comparison of Methods for Determining Soil Algal Biomass and Growth.

The methods for quantifying the soil algae are varied, and they may not be directly comparable. Each method has its advantages and limitations. Direct microscopic examination (light microscope or SEM) is often tedious, inaccurate and impractical. The most probable number (MPN) method fails to account for varying growth rates, morphological forms, and the nutritional requirements of the algae. The implanted slide technique tends to bias the results toward the forms that are motile and those algae that can adhere to the slide. However, the implanted slide technique is an efficient method for direct observation and quantification of soil algae as they are naturally arranged in the soil. The quantification of soil algae by the chlorophyll *a* extraction technique has been demonstrated to be the most reliable method. It allows for good replication, and it can be easily compared to data from other sites. It is advisable to acidify the extracts and measure for phaeophytin *a* to ensure accurate results.

D.B. STENGEL and M.J. DRING (School of Biology and Biochemistry, Queen's University, Belfast)

changed in the presence of blue light (Forster and DRING 1992, Plant Cell Environ. 15, 241-247). This hypothesis has been analysed in more detail. In pH drift experiments, the pH-compensation points were higher in the presence of blue light than in red light alone. Lowering the pH of the seawater increased overall photosynthesis but the blue light response was lost. At pH 8.5, blue light stimulated photosynthetic rates at DIC-concentrations of up to 10 mM, whereas no significant stimulation was seen at pH 6.5. The response to blue light was decreased in buffered seawater and it was almost completely suppressed by inhibitors of carbonic anhydrases. Active carbonic anhydrase is clearly necessary for the blue light effect, and we suggest that the external pH-shifts, which are also induced by blue light (Schmid and Dring 1993, Plant Physiol 101, 907-913), are required to maintain appropriate pH conditions for the activity of external carbonic anhydrase in the apoplast.

E. SERRÃO^{*,**}, L. KAUTSKY^{***}, and S.H. BRAWLEY^{*} (^{*}Dept. Plant Biology, Univ. of Maine, Orono, ME 04469, USA, ^{**}U.C.T.R.A., Univ. Algarve, 8000 Faro, Portugal, ^{***} Dept. Botany, Stockholm Univ., S-10691 Stockholm, Sweden).

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compared over salinities from 3‰ to 32‰. Motility of marine sperm was best at 32‰, and mostly zero at 6‰. Motility of Baltic sperm was best at 15‰, but still good at 6‰, and a small proportion still swim slowly at 4‰. Pronuclear migration in Baltic zygotes (13°C) was slower than for marine fucoids. Fertilization between Askö gametes (1000: 1 sperm:egg), assessed with calcofluor white, was more successful at and above 6‰ and very reduced at 4‰ and 3‰, which may be related to the swimming ability of the sperm. In summary, Baltic populations of *F. vesiculosus* have adapted to their low salinity habitats, but not fully, as their gametes perform better at salinities that are higher than those in which adults are found. Reductions in sperm motility may be an important factor in setting the northern limit of the species in the Baltic Sea. [Supported by the Natl. Geographic Soc. and NSF (S.H.B.), Fulbright and JNICT, Portugal (E.S.), and the Swedish NRC (L.K.).]

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D.B. STENGEL and M.J. DRING (School of Biology and Biochemistry, Queen's University, Belfast)

Impact of desiccation and high irradiances on photosynthesis and growth in *Ascophyllum nodosum*.

In Strangford Lough, Northern Ireland, *Ascophyllum nodosum* shows large variations in morphology, pigment content and photosynthetic characteristics between the upper and lower limits of its vertical distribution. Morphological variability decreased with shore height, possibly indicating a reduced genetic diversity of plants well adapted to extreme upper shore conditions. 88% of plants moved from lower to upper shore in June had died by the end of August, but all plants survived transplantation in the other direction or within a single shore height.

Length increase of individually marked tips of plants along a vertical transect was monitored over 2 years. Growth rates were lowest at the upper distribution limit and highest in the middle of the *Ascophyllum* zone, but varied with season in relation to climatic factors. There was a positive correlation of growth with temperature and sunshine in spring and autumn but, in summer, growth seemed to be inhibited by desiccation and high irradiance during periods of hot weather.

Under laboratory conditions, photosynthesis of all plants was inhibited after high irradiance ($2500 \mu\text{mol m}^{-2} \text{s}^{-1}$) and desiccation (20°C , 30% R.H.) treatments, but lower shore plants were less tolerant of longer desiccation times than upper shore plants. There was no significant difference in the rates of desiccation of upper and lower shore plants (58% fresh weight remaining after 2h, 30% after 6 and 12 h), but the rate and extent of recovery was greater in upper shore plants.

N.F. STEWART. (National Parks and Wildlife Service, Office of Public Works, 51 St Stephens Green, Dublin)

Red Data Books for Stoneworts and other lower plant groups.

In 1992 the "Red Data Books of Britain and Ireland Stoneworts" was published. This is intended to be the first of a series of Red Data Books covering lower plant groups. This paper will discuss the aims, methods and problems and will look at the possibilities for other algal groups.

L. SWAIN, D. J. ROGERS and A. T. CRITCHLEY* (School of Pharmacy and Biomedical Sciences, University of Portsmouth, England, *Botany Department, University of Witwatersrand, Johannesburg, R.S.A.).

Lectin-type haemagglutinins from *Pseudocodium devreisei*.

Lectins have been identified and characterised in extracts of several species from the genus *Codium* (Order: Caulerpales). These lectins bind N-acetyl- α -D-galactosamine (GalNAc) and do not require divalent cations in order to act as haemagglutinins. Species from other genera of the Caulerpales have not been studied for the presence of lectins in great detail.

Pseudocodium devreisei was collected from the coast of Isipingo, Natal, South Africa, freeze-dried and stored at 18°C . Freeze-dried alga, 1g, was ground to a fine powder and extracted with 5 ml 0.17 M phosphate-buffered saline (pH 7.3). Supernatant fluid agglutinated papain-treated human erythrocytes strongly. No ABO blood group specificity was demonstrated. Haemagglutination occurred in the presence of EDTA and was not inhibited by GalNAc, N-acetyl- α -D-glucosamine, fucose or galactose.

The absence of inhibition of the haemagglutinins from *P. devreisei* by GalNAc clearly distinguishes them from the well-characterised lectins from *Codium* species and indicates that quite distinct lectins are present in other genera of the Caulerpales.

I. TITTLE and S. FOWLER (The Natural History Museum and The Nature Conservation Bureau)

The marine nature conservation importance of chalk coasts.

Although the 'White Cliff' coastline of Britain is world-renowned, chalk forms only 0.6% of the total British coastline and is very restricted in occurrence in continental Europe. Unlike terrestrial chalk habitats, marine chalk communities have not received the same degree of attention. The accelerated loss of chalk coastal habitats, especially in south east England has given cause for concern. In Kent 56% of the coastline has been modified by coastal works, 33% in Sussex.

A unique feature of coastal chalk is the micro-algal flora first described by Anand in the 1930s. Most of his sites of investigation have been destroyed and small remaining extent of type localities are threatened. Recent preliminary investigations have revealed similar communities at Flamborough to the north and Dorset to the west, and suggest taxonomic reevaluation is required. The macro-algal flora is poorer in

species in comparison to the geologically harder southwest and west coast sites. Several species reach their northern (e.g. *Gastroclonium reflexum* in Norfolk) and southern (e.g. *Ptilota plumosa* at Flamborough) distributional limits on chalk shores.

**I. TITTLE (The Natural History Museum)
Seaweed species richness and diversity in the North Atlantic: implications for conservation.**

1150 species of benthic macroalgae have been recorded for the North Atlantic (north of latitude 38°). The European Atlantic coast is much richer in species than the American with 60% of North Atlantic species restricted to the European coast, 35% common to both sides and 5% only on the American coast. This is reversed in warmer waters to the south where the American-Caribbean coast is much richer in species than the African coast. A gradient of decrease in species richness occurs from south to north along both coasts but more noticeably in Europe. The Arctic has a relatively depauperate flora of hardy, weedy species; endemism there is low. Recent numerical analyses suggest biogeographical regions may not be distinct; much of the Norwegian algal flora is shared with England. Species 'hot-spots' in the North Atlantic are the coasts of northern Spain, France and England. The global distributions of several species (e.g. *Delesseria sanquinea*, *Himantalia elongata*) are restricted to the eastern Atlantic. If species-richness is an important criterion in marine conservation, then attention should be focussed on Spain, France and Britain, areas where also anthropogenic disturbance is significant.

B.A. WARD and C.A. MAGGS. (School of Biology & Biochemistry, The Queen's University of Belfast).

Plastid DNA restriction fragment size analysis demonstrates species complexes in the genus *Ceramium*.

For the past two centuries the genus *Ceramium* has remained in a state of taxonomic chaos because of the high level of intraspecific morphological variability. In the British Isles it has been difficult to determine the number of species in the genus and in recent years estimates have varied between 2 and 21. It was thought that the genus could only be separated into two

species complexes called *Ceramium rubrum* and *C. diaphanum/strictum*. Previously, we have discussed the usefulness of plastid DNA restriction banding patterns as a species indicator. We found that each species in this genus had a unique plastid DNA banding pattern. The relationships between these species are now being investigated by comparing the degree of plastid DNA band sharing between each species of *Ceramium*. From this data, similarity coefficients are calculated and the species are grouped using UPGMA analysis. This analysis does not support the 2 previously recognized complexes of *C. rubrum* and *C. diaphanum/strictum*. Instead there appear to be two other groupings of species; species within these groups are related to each other to varying degrees. The first group contains species that would have previously been grouped in either *C. rubrum* or *C. diaphanum/strictum*. The second group consists of species that would previously been placed in the *C. rubrum* complex or the group of *Ceramium* species with spines. In addition to these 2 complexes, there are also 5 species of *Ceramium* that are not closely related to either of these 2 groups nor to each other.

A.J. WHISTON, P.J. McAULEY and V.J. SMITH (School of Biological and Medical Sciences, University of St Andrews, St Andrews, Fife KY16 9TH)

Removal of heavy metals from wastewater by marine microalgae.

Biologically based primary sewage treatment systems almost all rely on aerobic digestion using heterotrophic bacteria. While this is very effective at reducing BOD it does little to remove nutrients and toxic substances, including heavy metals. The use of microalgae to remove nutrients and photo-oxidise sewage is now almost common practice as a tertiary stage, but the ability of the microalgae to remove heavy metals is little explored. Preliminary mass screening of 206 species of marine microalgae identified a number of species which were able to grow on primary sewage diluted 1:1 with seawater containing a cocktail of heavy metals (including Cd, Cu, Fe, Mn, Pb), and to remove metal ions from solution. Removal was found to be rapid: cultures containing 10^6 cells ml⁻¹ removed virtually all metal ions from solution at 10 ppm within 5 minutes. In some species metal removal was accompanied by an increase in the levels of extracellular protein in the culture. SDS PAGE

electrophoresis revealed that this was due to the release of a low molecular weight protein by the algae. Preliminary characterisation and the possible metal binding role of this protein will be discussed.

M. WILKINSON (Heriot-Watt University, Edinburgh)

Factors affecting productivity of algae in estuaries

Most studies on estuarine algal productivity relate to phytoplankton in the relatively saline waters around the estuary mouth. Environmental conditions such as turbidity, salinity and water column stratification may be very different in the estuary proper, as may be the availability and stability of habitats such as intertidal flats. This may result in a shift of the balance of productivity towards benthic algae. Productivity may be influenced by man, not only by pollutant inputs, but also by modifications to the physical regime such as construction of tidal barrages.

S.B. WILKINSON. (DEEB, Liverpool University).

Patterns of algal colonisation in a eutrophic estuarine docks complex.

Following a period of disuse, the Liverpool South Docks complex was finally dredged out and refurbished in 1985. While the docks remained essentially isolated from the Mersey the water level was periodically topped up with water from the river thus allowing the entry of algal diaspores. The benthic algal flora present is comprised of about thirty species, mostly ephemeral. Perennial macrophytes are still to establish. Beginning in March 1993 temporary settlement panels were deployed at a range of depths from the surface to 1.5 m and exchanged at monthly intervals. Standing crop and species composition were determined. Preliminary results indicate that algal settlement is not random but follows a seasonal cycle. Colonisation reflects physio-chemical conditions in the docks and seasonal availability of diaspores.

D.M. WILLIAMS. (Department of Botany, The Natural History Museum, London).

Progress in diatom classification? Araphid diatoms systematics.

It is now well established that the diatoms

are a monophyletic group, with evidence coming from morphology, cytology and, more recently, molecules. Historically, there have been three major taxonomic divisions within diatoms initially based on the symmetry of the cell walls: Pennate diatoms exhibit bilateral symmetry while centric diatoms exhibit radial symmetry. Pennate diatoms have been further subdivided into the raphid diatoms (those with a slit in the cell wall [the raphe]), and the araphid diatoms (which lack this structure). Not all classifications agree with this tripartite division and, alternatively, the araphid diatoms have been placed in a series of sub-orders of equal rank to those of the centric and pennate diatoms. Theories on the origin of the raphid diatoms are usually expressed in terms of either araphid ancestors or of the araphid diatoms being a 'transitory' group straddling the centric and raphid pennate groups. Such notions imply that the araphid diatoms are a paraphyletic group: a taxonomic group with no characters of its own.

I will present some evidence to show that this stalemate is largely due to a neglect in the analysis of data, rather than in its acquisition.

Y. WU, C.A. WHAPHAM, G. BLUNDEN, T. JENKINS and S.D. HANKINS (School of Pharmacy & Biomedical Sciences and School of Biological Sciences, University of Portsmouth; Maxicrop International Ltd., Corby)

The role of betaines in seaweed extracts in the reduction of *Meloidogyne javanica* infestations of tomato plants.

The numbers of eggs of the root-knot nematode, *Meloidogyne javanica*, recovered from tomato plants treated with seaweed extract were significantly reduced after one generation when compared to those plants treated with water alone. Betaines, when applied to plants, have been shown to reduce the levels of infection with certain fungi and viruses and the possibility that these compounds may also reduce the severity of nematode attack was considered. Commercially available seaweed extracts (Maxicrop International Ltd.) derived from *Ascophyllum nodosum* were evaluated, as were three betaines (glycinebetaine, τ -aminobutyric acid betaine and δ -aminovaleric acid betaine), which were applied in quantities equivalent to those present in the seaweed extracts. Reductions in the fecundity of the root-knot nematode were obtained with the use of the seaweed extracts and each of the three betaines. This suggests that the effects on

nematodes produced by the seaweed extract were due, at least in part, to their betaine content.

J. YELLOLY and B.A. WHITTON. (Department Biological Sciences, Durham University, South Road, Durham DH1 3LE, U.K.)

Phosphorus ecology of intertidal and stream *Rivularia* populations.

Previous studies have suggested that Rivulariaceae favour habitats where the concentration of ambient P is highly variable and often with a high proportion present as organic P. In order to investigate this further, a one-year study was made at two *Rivularia* sites, the upper intertidal region at Tyne Sands, E. Lothian, and an Upper Teesdale stream. Measurements were made of water chemistry, surface phosphatase activities of *Rivularia* and some adjacent organisms, and morphological features of *Rivularia*.

An important source of P at the marine site is apparently the large masses of decomposing seaweed deposited in storm events; P in the stream is probably derived from peat. At both sites ambient P ranged up to two orders of magnitude. Organic P was overall an important fraction at both sites, though peaks at the marine site ranged from largely inorganic to largely organic. Colony formation was most obvious following pulses in environmental P; phosphatase activities per unit biomass (measured as chlorophyll *a*) increased markedly soon after, in some cases reaching their maximum level for the year.

POSTERS.

C.J. BARWELL and E. M. CUNNINGHAM (Marine Natural Products Research Group, Pharmacy & Biomedical Sciences, University of Portsmouth.)

Isolation and some properties of R-phycoerythrin from *Palmaria palmata*.

As part of an EC MAST funded project, we are evaluating European marine algae as sources of biliproteins. We have isolated and characterised phycoerythrin from *Palmaria palmata*, a red alga which is abundant on rocky shores of the European Atlantic coast. Fresh algae were extracted with 0.05M sodium phosphate pH 6 and the extract processed by centrifugation, filtration and dialysis. Phycoerythrin was separated from phycocyanins and purified by a combination of anion exchange

chromatography upon Q-Sepharose and size exclusion chromatography with Sephacryl S-200.

The absorbance spectrum exhibited maxima at 494 nm and 565 nm and a prominent shoulder at 540 nm, typical of R-phycoerythrin type 1. The ratio, OD₅₆₅ nm to OD₂₇₈ nm of the product, was 5.3. The molecular weight of the native protein, determined by HPLC size exclusion column chromatography, was 205,000 daltons. Denaturing SDS PAGE yielded three components (α , β and τ -subunits) with apparent molecular weights of: 32,000; 17,000 and 13,400 daltons which, based upon an assumed subunit composition of ($\alpha\beta$)₆ τ , yields a calculated native molecular weight of 115,300 daltons.

C.J. BARWELL, S. SAKER-SAMPAIO*, D.J. ROGERS, D. BRAULT** and S. MABEAU** (Pharmacy & Biomedical Sciences, University of Portsmouth, *Universidade Federal do Ceara, Brazil and **Centre D'etude et de Valorisation des Algues, Pleubian, France.)

Biochemical evaluation of some edible European marine algae.

We have studied the occurrence of inhibitors of the digestive enzyme trypsin and the pro-vitamin A carotenoids α -carotene and β -carotene in *Palmaria palmata* and *Laminaria digitata*. These European marine algae have similar appearance and texture to Pacific algae which form the basis of an extensive human food products industry. In addition, they are abundant in European coastal waters.

Fresh algae were extracted and the fractionated extracts assayed for trypsin inhibitors and the pro-vitamin A carotenoids. Both *P. palmata* and *L. digitata* were apparently free from trypsin inhibitors. Each of six samples of *P. palmata* contained both α -carotene (20-60 $\mu\text{g/g}$ dry wt.) and β -carotene (60-160 $\mu\text{g/g}$ dry wt.) whilst samples of *L. digitata* from the same locations contained only β -carotene (150-280 $\mu\text{g/g}$ dry wt.). These levels of pro-vitamin A carotenoids are similar to those present in edible Pacific algae and some higher plants which are regarded as good dietary sources of vitamin A.

R. BHODAY, L.R. JOHNSON, S.J. RUSSELL, P. GACESA* and D.M. JOHN (Department of Botany, The Natural History Museum, London, UK and *Department of Biochemistry, University of Wales College of Cardiff, Cardiff, UK)

Genomic variation in *Pseudendoclonium* and

***Dilabifilum* (Chaetophorales, Chlorophyta): taxonomic implications concerning accepted species concepts.**

Morphological traits are still used for characterisation of structurally simple filamentous algae traditionally attributed to the Chaetophorales despite limited understanding of their variability. Significant morphological variability was exhibited by isolates of *Dilabifilum* and *Pseudendozonium* from different regions and a wide range of habitats when cultured under experimental laboratory conditions. Genomic variability of the isolates was examined by comparing the patterns obtained by the restriction analysis of nuclear encoded 18S rRNA using four- and five-base-pair cutting endonucleases. The isolates attributed to the morphologically-defined 'species' within the two genera were grouped based on restriction patterns. There was found to be often little or no congruence between morphological and gene sequence data so bringing into question current species concepts in the genera.

J.L. BRENCHLEY, J.A. RAVEN, and A.M. JOHNSTON. (Department of Biological Sciences, University of Dundee)

Oxygen exchange and growth rate characteristics of *Himantalia elongata* during reproductive development, in comparison to non fertile plants.

The initiation of receptacle development is well synchronized in the *Himantalia elongata* population at Fife-Ness (N.E.Scotland). The majority of vegetative buttons greater than 20 mm diameter begin to form 'thong' like receptacles in the winter. Small buttons which do not become reproductive remain in the vegetative state until the following year.

The relative growth rate and oxygen exchange characteristics of both non fertile and fertile plants of *Himantalia elongata* were determined throughout the period of reproductive development, from February to July 1993.

The receptacle 'thong' is highly photosynthetic and correspondingly exhibits high growth rates, especially during March and April, after which maximum photosynthetic rate (P.max) and growth rate decrease as the receptacle begins to mature.

The development of the receptacle appears to have a detrimental effect on the vegetative button of the fertile plant. The growth rate of the vegetative button during the earlier stages of

receptacle development is negligible, however in the latter stages of development, the button shows signs of decay, ie. minus growth rates.

In comparison to the fertile vegetative button the non fertile button has a higher P.max, respiration and relative growth rates, all of which peak during April/May, but remain relatively high throughout the monitoring period.

D.E. CARNE, D.M. JOHN, R. HUXLEY, L.R. JOHNSON and J.A. MOORE (Department of Botany, The Natural History Museum, London, UK)

William and George West: an analysis of their publications, collections and taxa.

William and George S. West were two of the leading figures in phycology during the early years of this century, with their contribution to our understanding of British freshwater algae remaining unsurpassed. In their quest for material they visited some of the remoter areas of the British Isles and received collections from many parts of the world. The West's wrote over 140 papers and their books included the 5-volumed "British Desmidiaceae", and George West's "A Treatise on the British Freshwater Algae" (second edition with F. E. Fritsch). In their publications on British algae over 550 taxa were described of which over 210 were at the species level (ca 60% desmids). A critical examination of their published work has revealed that about half of their new taxa are still recognised; many other have changed their status or been recombined. Much of the West's type material has been verified in a search of their collections housed in the Natural History Museum. A bibliography, the described taxa and their current status, lists of types, and ecological and distribution data have been incorporated into a relational database. This research forms part of an on-going project to catalogue algal types and represents a contribution towards the British Freshwater Algal Project.

K. CHILDS (Department of Botany, The Natural History Museum)

Important New Acquisitions to the Diatom Collections and the BMLOC Database at the Natural History Museum.

The Botany Department at The Natural History Museum houses one of the largest diatom collections in the country. In the last two years several large recent collections have been

acquired, two of the most important of which are Roger Flower's Lake Baikal Collection and Imperial College's Pamir Expedition Collection from the Himalayas. These localities are sparsely represented in our previous holdings. The method of cleaning and mounting these new acquisitions is described.

In recent years there has been an increasing need to find modern forms of information storage and retrieval to facilitate speedy access to the collections. Using the new acquisitions as a starting point, the locality and habitat details of these and other samples have been entered into the BMLOC database which now has over fourteen thousand records. The processing and data capture of the new material are also described.

P.A. COURSE, G.A. TARRAN and J.C. GREEN (Plymouth Marine Laboratory, Plymouth PL1 2PB)

The life history of *Emiliania huxleyi*: Evidence for haploid and diploid states using flow cytometry.

The ubiquitous coccolithophorid *Emiliania huxleyi* exists in several forms: (a) non-motile coccolith bearing cells (C-cells), (b) non-mottled naked cells (N-cells), and (c) flagellate scale-bearing cells (S-cells). The relationships between these cells are not clear, it is known that C-cells can give rise to N-cells and S-cells in culture, and that occasionally C-cells can be obtained in cultures of S-cells. In order to determine whether a sexual cycle is involved, experiments have been carried out to determine the relative DNA content of C- and S-cells by using flow cytometric analysis of fluorochrome-stained DNA. It has been shown that S-cells show peaks at channels 30 and 60 on a 256 channel scale, representing G1 (pre-DNA synthesis) and G2 (post-DNA synthesis/pre-mitosis) stages of the cell cycle. C-cells have peaks at channels 60 and 120. S-cells therefore contain half the DNA content of the C-cells and are haploid relative to C-cells. They may represent a gamete stage, though they themselves undergo mitosis and reproduce vegetatively. C-cells also reproduce by vegetative mitosis, but they may also be the result of gametic fusion or, possibly, the transformation of a haploid cell at the G2 (pre-mitosis) stage.

E. DELPHIN and R.L. FLETCHER (The Marine

Laboratory, University of Portsmouth)

The influence of substratum surface wettability on algal spore settlement and germination.

A study was carried out on the influence of substratum surface energy on the settlement and development of some marine algae. A range of surface energies (defined in terms of the related parameter "wettability") was provided by a total of 9 different substrata which included a selection of polymeric solids (e.g. polystyrene, polypropylene) and glass, these giving a wide range of contact angle measurements, viz. 50-109°. All surfaces were inoculated with spores of 4 macroalgal genera (viz. the green alga *Enteromorpha*, the brown algae *Petalonia* and *Scytosiphon* and the red alga *Polysiphonia*) and placed under suitable culture conditions.

Two diverse basal developments were observed for each alga on the materials i.e. short, compact, well-adhered structures (usually found on intermediate or high wettability materials), and spreading, filamentous or knot-filamentous, loosely-adhered structures (usually found on low wettability materials). Some materials, however, e.g. acrylic, did not conform to their wettability type, suggesting that the surface chemistry was also important. Some preliminary observations also indicated that the settling behaviour of motile algal spores was influenced by surface wettability.

J.M. GOROSTIAGA (Dep. Plant Biol. & Ecol., Fac. Sci., Univ. Basque Country, Ap.644 Bilbao,48080, Spain)

***Fucus chalonii* or *Fucus vesiculosus* var. *linearis*?**

The species of *Fucus chalonii* J. Feldm. was attributed to reduced forms of *Fucus* living in the low eulittoral zone of a very exposed shore along a stretch of 2 km close to Hendaye, in the French Basque coast (Feldmann, 1941). Since then no other location for this *Fucus* has been reported. This taxonomic entity was later included into *Fucus vesiculosus* L. var. *linearis* (Hudson) Powell under the hypothesis that this dwarf form was caused by the exposure to the waves (Powell, 1963). However, no experimental work supported this hypothesis. The discovery of an extensive population of this *Fucus* (*F. chalonii* var. *minus*) on a semi-exposed shore with relatively low surf on the Spanish Basque coast (100 Km away from the original finding) made us doubt that exposure is the causal factor modifying the habit of the plant and subsequently raised doubts on the true taxonomic entity of this *Fucus*.

Important aspects of its morphology, biology and ecology differ markedly from those of *F. vesiculosus*. This dwarf *Fucus* presents an extensive basal disk, with numerous erect fronds arising from it. Its fertility period is from summer to late autumn. Its habitat corresponds to the low eulittoral zone, below the *Chthamalus* belt, from very exposed to semi-exposed conditions on a soft rocky substratum of clayish nature. Transplant and culture experiments, together with the detection of genetic markers will be carried out in order to elucidate the taxonomic position of this reduced form of *Fucus*.

P. GUENEAU and R.L. FLETCHER (The International Marine Centre, Torregrande, Oristano, Italy and the Marine Laboratory, University of Portsmouth, U.K.)

Cryopreservation of *Enteromorpha* zoospores: a Preliminary study.

Major constraints on the use of marine macroalgae as laboratory based bioassay organisms include the often restricted seasonal occurrence of suitable test material and the difficulty in obtaining sufficient inocula (particularly reproductive spores) for the tests. The present study was, therefore, undertaken to examine the feasibility of using cryopreservation techniques for storing test inocula.

Settled *Enteromorpha* zoospores were cooled slowly to -20°C and -80°C in 0-25% solutions of the cryoprotectants glycerol and dimethyl sulphate (DMSO). After rapid thawing the spores were cultured and the % germination assessed after 3 days. In general the results revealed that zoospores could be frozen and stored successfully. Improved viability was obtained using low concentrations of cryoprotectant with DMSO providing more effective than glycerol; maximum germination (75%) was recorded using 5% DMSO and when cooled to -20°C .

M. HARKER, A.J. TSAVALOS, and A.J. YOUNG. (School of Biological & Earth Sciences, Liverpool John Moores University, Byrom Street, Liverpool. United Kingdom L3 3AF)

Optimisation of astaxanthin production in *Haematococcus pluvialis* using response surface methodology.

The freshwater microalga *Haematococcus pluvialis* accumulates the ketocarotenoid astaxanthin ((3S, 3'S)-3,3' dihydroxy

- β,β -carotene-4,4'-dione), when exposed to various nutritional and environmental stress conditions. The astaxanthin is present in various esterified forms, usually with small amounts of closely related carotenoids (e.g. canthaxanthin, adonirubin and echinenone). The effect of urea, salt and light on the accumulation of these secondary keto-carotenoids in *H. pluvialis* has been investigated using response surface methodology (RSM). All three parameters, independently, were found to be important for the induction of secondary carotenoid synthesis. Using RSM the optimum level of each key independent variable has been determined. Identification of an optimum using RSM requires that each variable be tested at at least three levels and in all combinations. The results obtained will be discussed.

R.M. HEAD, R.I. JONES and A.E BAILEY-WATTS* (Department of Biological Sciences, I.E.B.S., Lancaster University. *I.F.E., Edinburgh)

The role of recruitment from the benthos in the population dynamics of blue-green algae in a mesotrophic lake.

A number of species of planktonic cyanobacteria are known to produce akinetes (spores) or viable cells that sediment out of the water column and survive in the sediments. This benthic period in the life-history of some blue-green algae may provide a source of recruitment for the next planktonic growth phase.

During the spring and autumn circulation resuspended cells and filaments can serve as one source of inocula from pelagic populations. Recent work suggest migration of cells from viable akinetes in the littoral sediments of lakes after germination also occurs, although quantitative evidence is poor. In addition to this, colonies of blue greens have been found growing on sediment surfaces prior to migration into the water column. The factors which initiate such a movement are poorly understood, as is the role of migration within the life history of the species involved, as both a recruitment strategy and adaptive behaviour.

To assess the extent of benthic migration of blue green algae occurring from the benthos of a mesotrophic lake and the species involved, a series of trapping experiments were undertaken. Specially designed traps were deployed at four depths towards the northern end of Esthwaite Water in Cumbria. Trapping was carried out

during a 6 month period from April until October 1993 in conjunction with monitoring of environmental factors.

A.J. HUTCHINGS and H. BELCHER (National Rivers Authority (Thames Region) Cambridge Fobney Mead, Reading, RG2 OSF)

A Baseline Study of the Phytoplankton in the River Thames.

The freshwater River Thames is a highly-regulated, eutrophic, lowland river. Along its 243 km length there are 44 locks, which under certain conditions cause the river to behave like a chain of ponds. This results in the development of a true phytoplankton community.

Initial results of a two year project aimed at identifying seasonal and longitudinal changes in phytoplankton populations in the river Thames are shown. Twelve sites along the river from Somerford Keynes, (8 km from the source), to Kingston Bridge, (241 km the source), were studied at fortnightly intervals. The aim was to provide information on the phytoplankton of the River Thames for use in surface water management; in particular the proposed construction of a reservoir (150,000 MI or 33,000 million gallons capacity) South West of Abingdon. The reservoir will receive river water during high flow conditions and will discharge water to the river during low flows so that abstraction can continue at downstream locations.

This study forms part of a general investigation into aspects of the River Thames biology being undertaken by the National Rivers Authority and Thames Water Utilities P.L.C.

G.M. KENNAWAY, P.TETT* and I.A.N. LUCAS* (Royal Holloway and Bedford New College, University of London and *University College of North Wales, Menai Bridge, Gwynedd).

Flagellates of the sub-tropical Atlantic.

During the cruise, Canarias 9308 (4-28 August, 1993. MAST project 0031) water samples were collected and preserved for a scanning electron microscope (SEM) study of diversity among ultra-flagellate species (<20 μ m in linear dimension) associated with four bio-geographical regions found between the Canary Islands and the north west coast of Africa.

The study showed striking qualitative similarities in the flagellate assemblages of the mixed and stabilised waters of the ocean. Species

diversity in each of the regions was relatively low, confined to 5-6 species and the occurrence of some species such as *Phaeocystis*, *Rhinomonas* and *Chrysochromulina* was common to all the regions. Also commonly occurring were small cells (2 μ m) with oval lobed bodies and long flagella. Comparisons with the flagellate assemblages of Loch Striven 1990, a shelf sea location off the north west coast of Scotland, U.K., showed that species diversity was also relatively low and that a few phytoplankton types (Prymnesiophyceae and Cryptophyceae) were temporarily and spatially ubiquitous and often abundant. The very small flagellates, which occurred in Loch Striven during mid-June were identified as being photosynthetic. These cells were 2.0 μ m in length, oval, in shape with two short equal flagella, apically inserted which characteristically curled round the body of the cell. Many of the smallest flagellates from all the sampling region remain identified.

The similarities in composition of the flagellate assemblages despite differences in the turbulent mixing characteristics and nutrient status of the oceanic regions and the shelf sea indicates that these ultraplanktonic cells may exist in a domain in which eddy diffusion is not the most important forcing factor.

J.H. KINROSS, N. CHRISTOFI and P.A. READ. (Department of Biological Sciences, Napier University, Edinburgh)

Growth Rate Measurement in Attached Filamentous Algae.

Attached filamentous algae present particular problems in growth rate measurement, in comparison with planktonic forms. Since it is difficult to achieve even colonization of substrata, measurement of increment in biomass by pigment extraction is impracticable.

One alternative is to measure the growth rate of individual algal filaments attached to microscope slides by periodic counting of cell numbers under the microscope. Individual filaments can be located by their coordinates on the stage micrometer. A major advantage of this method is that mixed cultures can be used, and in fact this is an aid in re-locating filaments.

We have used this method to determine the response of growth rate in several algal taxa to variation in pH and aluminium concentration. Results indicated that algae common at low pH (4.0 to 5.0) had a higher growth rate than

circumneutral taxa in this pH range, and vice versa. The response to raised aluminium concentrations further helps to explain community composition in the field. These measurements were made in miniature recirculating channels with artificial streamwater, but the method is potentially applicable to field studies also.

R.E. KORB^{*}, J.A. RAVEN^{*}, A.M. JOHNSTON^{*} and J.W. LEFTLEY^{**} (Department of Biological Sciences, University of Dundee, Scotland and ^{**}Dunstaffnage Marine Laboratory, Scotland)

Growth rate and ¹³C/¹²C discrimination in relation to diatom cell size.

Measurements on marine phytoplankton show a ¹³C distinction between fast-growing diatoms with ¹³C-rich contents and slow growing diatoms that were depleted in ¹³C. Variations in specific growth rate, surface area to volume ratio and boundary layer thickness may contribute to the differences in ¹³C/¹²C ratios in diatoms. In preliminary studies, the large celled diatom *Ditylum brightwelli* with a cell volume of ~8713 μm³ and the small celled diatom *Chaetoceros calcitrans* 38 μm³ were grown in aerated batch cultures and specific growth rate was measured by making daily cell counts and chlorophylla measurements. The average isotopic values were significantly different (t test, p < 0.05) between *D. brightwelli* with a value of -25.7‰ ± 1.4 and *C. calcitrans* -19.4‰ ± 4.2. The small celled diatom with the ¹³C rich value had a higher specific growth rate (μ) of 1.31 d⁻¹ than the large celled diatom, 0.97 d⁻¹ when (μ) was calculated from cell counts. This data would agree with the suggestion that isotopic fractionation is inversely related to growth rate. However, when μ was calculated from chlorophylla, specific growth rates were higher in *D. brightwelli* at 2.14 d⁻¹ compared to 1.23 d⁻¹ for *C. calcitrans*. Further work is needed to investigate the relationship between ¹³C/¹²C ratios and growth rate, including a knowledge of the physiology and biochemistry of photosynthesis of these diatoms.

Y. MA, C.J. BARWELL and G. BLUNDEN (School of Pharmacy & Biomedical Sciences, University of Portsmouth)

Carotenoids from *Palmaria palmata* and *Halidrys siliquosa*.

The carotenoid contents of one red alga

(*Palmaria palmata*) and one brown alga (*Halidrys siliquosa*) have been studied. The compounds were extracted from the algal material with methanol containing 10% pyrogallol as an antioxidant. The extracts, after saponification by heating with aqueous potassium hydroxide solution, were partitioned with n-hexane. The n-hexane extract, containing the carotenoids, was then fractionated by preparative high-performance liquid chromatography (HPLC). The major carotenoid isolated from *Palmaria palmata* was lutein. The HPLC fraction which yielded lutein also contained another major component which, from mass spectrometric and nuclear magnetic resonance spectroscopic data, was proved to be 7-oxo-desmosterol. The major carotenoid isolated from *Halidrys siliquosa*, although in low yield, was zeaxanthin. This has been reported as a minor carotenoid of brown algae and the suggestion has been made that it is an artefact produced during extraction and isolation by reduction of violaxanthin. The HPLC fraction from which zeaxanthin was isolated also yielded gamma-tocopherol; this latter component was characterised by mass spectrometry and nuclear magnetic resonance spectroscopy.

J.A. MOORE. (Department of Botany, The Natural History Museum)

Collections old and new at the Natural History Museum.

The collections of algae held at the Natural History Museum in London [formerly the British Museum (Natural History)] are extensive and include holdings of international importance. A large number of type specimens are deposited in the collections and material is available on loan to researchers throughout the scientific community. Examples of some recent additions are shown along with the preliminary findings of a long-term research project investigating the preservation of older collections. One of a series of initiatives now being pursued by the curation team is an authoritative review of the conservation of Museum specimens, with particular emphasis on liquid preservation procedures.

The whole process from field collection of fresh material to the accessioned sheet, bottle or slide is being investigated.

R.M. READ, R.I. JONES and A.E. BAILEY-WATTS* (Department of Biological Sciences, I.E.B.S., Lancaster University. *I.F.E.,

Edinburgh)

The role of recruitment from the benthos in the population dynamics of blue green algae in a mesotrophic lake.

A number of species of planktonic cyanobacteria are known to produce akinetes (spores) or viable cells that sediment out of the water column and survive in the sediments. This benthic period in the life-history of some blue-green algae may provide a source of recruitment for the next planktonic growth phase.

During the spring and autumn circulation resuspended cells and filaments can serve as one source of inocula from pelagic populations. Recent work suggests migration of cells from viable akinetes in the littoral sediments of lakes after germination also occurs, although quantitative evidence for this is poor. In addition to this, colonies of blue greens have been found growing on sediment surfaces prior to migration into the water column. The factors which initiate such a movement are poorly understood, as is the role of migration within the life history of the species involved, as both a recruitment strategy and an adaptive behaviour.

To assess the extent of benthic migration of blue green algae occurring from the benthos of a mesotrophic lake and the species involved, a series of trapping experiments were undertaken. Specially designed algal traps were deployed at four depths towards the northern end of Esthwaite Water in Cumbria. Trapping was carried out during a 6 month period from April until October 1993 in conjunction with monitoring of environmental factors.

R.H. REED, P.J. WRIGHT*, J.A. CHUDEK** and G. HUNTER** (Biomedical Sciences Group, University of Northumbria at Newcastle, *School of Biological Sciences, University of Birmingham and ** Department of Chemistry, University of Dundee).

Application of ^{13}C nuclear magnetic resonance spectroscopy to low molecular weight carbohydrate metabolism in marine brown algae.

The top-shore alga *Fucus spiralis* contains mannitol as the single most important low molecular weight organic solute while the lower-shore alga *Himantalia elongata* contains two isomeric hexitols (mannitol and altritol) as major internal organic osmotica. We have studied the effects of salinity on the turnover of carbon within the intracellular pools of low molecular

weight solutes in these two algae, using ^{13}C -labelled NaHCO_3 and NMR spectroscopy. *F. spiralis* in full-strength sea water (35‰) showed a major ^{13}C input to mannitol, with a half-time turnover rate ($t_{1/2}$) of ≈ 20 h. In response to salinity upshock (70‰), the mannitol assimilation rate increased while the mannitol dissimilation rate remained approximately constant. Mannitol turnover in *H. elongata* maintained in sea water was somewhat slower, with a $t_{1/2}$ for mannitol assimilation of ≈ 70 h and a $t_{1/2}$ for altritol of > 200 h. In response to salinity upshock, the mannitol assimilation rate showed a greater proportional increase than that of altritol, consistent with natural abundance ^{13}C NMR data indicating the preferential use of mannitol in osmotic adjustment under hypersaline conditions.

G. REID. (Department of Botany, The Natural History Museum)

The Ecology of edaphic diatom communities from two salt marshes.

The edaphic diatom flora of two salt marshes on the Isle of Sheppey, Kent, are being investigated. Stations along transects (one per marsh) are being sampled on a quarterly basis for quantitative estimates of the diatom communities. Concurrent field measurements of temperature, salinity, pH and conductivity are taken at each station. Floristic changes along each transect, and between the two marshes will be described, in relation to change in the physics-chemical environment. Preliminary results of culture work, (manipulating salinity, temperature and light) will also be presented. This is being undertaken to elucidate the physiological adaptations of individual taxa, and to investigate any morphological plasticity.

R. SCHMID and M. J. DRING (School of Biology and Biochemistry, Queen's University of Belfast)

Influence of inorganic carbon supply on stimulation of photosynthesis by blue light in *Ectocarpus*.

As in *Laminaria* (Dring 1989, J. Phycol. 25, 254-258), blue light stimulates the photosynthesis of *Ectocarpus* at saturating irradiances of red light. However, *Ectocarpus* is ten times more sensitive to blue light than *Laminaria* and responds more rapidly (lag phase after the beginning of blue light is about 10 s in

Ectocarpus, compared to 2 min in *Laminaria*). In *Ectocarpus*, blue light stimulation compensates almost exactly for a circadian rhythm of photosynthesis seen in red light (Schmid and Dring 1992, *Planta* 187, 53-59). In contrast to *Laminaria*, buffering of the seawater did not affect the response to blue light, and inhibitors of external and total carbonic anhydrases had differential effects. There was a clear, but incomplete, inhibition of stimulation of photosynthesis by blue light only when total carbonic anhydrase activity was inhibited by ethoxzolamide (EZ). The amplitude of the circadian rhythm of photosynthesis in red light was also more strongly reduced by EZ than by acetazolamide (AZ). At low pH, the blue light response (as well as circadian rhythmicity) was suppressed, but only at dissolved inorganic carbon concentrations greater than 1 mM. The suppression appeared to result from adaptation to elevated levels of CO₂. The mechanism by which blue light enhances photosynthesis in *Ectocarpus* would seem, therefore, to involve the activation of an internal carbonic anhydrase.

C. SCOTT, G.B. BREMER and R.L. FLETCHER (The Marine Laboratory, School of Biological Sciences University of Portsmouth)
Observations on attachment mechanisms of marine blue green algae (Cyanophyceae).

Despite their importance as primary producers in oceans, the marine blue-green algae remain a poorly understood group. They however form a significant component of biofilms of newly immersed surfaces of both toxic and non-toxic materials. This investigation was aimed at determining the mechanisms by which these microscopic organisms attach to and colonise surfaces over a period of time. Uni-algal cultures of prominent fouling species were used throughout the study. They were obtained from biofilm samples removed from fixed and floating structures in Langstone Harbour (S. England).

The cultures were inoculated onto Thermanox coverslips to promote settlement and incubated for 8, 24, 48 hours and for periods of 3 to 10 days. The coverslips were then prepared for either light microscopy or scanning electron microscopy (S.E.M). Results are presented for the filamentous species of the genera *Phormidium*, *Plectonema* and *Calothrix* and colonial coccoid species of the genera *Xenococcus* and *Dermocarpa*. Trichomes of *Phormidium* were firmly attached after 8 hours settlement whereas

the larger filamentous and colonial forms require longer periods for attachment. S.E.M. studies revealed that all the species investigated produce extracellular material to aid attachment. In some cases, this material was copious, e.g. *Dermocarpa* in other isolates its production was restricted to the immediate vicinity of the filaments.

G.W. SCOTT, and F.G. HARDY (Dept. of Environmental Science, University College Scarborough. Dept. of Marine Sciences and Coastal Management, University of Newcastle upon Tyne)

Observations of the occurrence of hybrids between two sympatric species of Furoid algae

Anderson's Hybrid Index method was used to identify plants of *F. spiralis*, *F. vesiculosus*, and hybrids between the two species, collected from two areas of Great Cumbrae Island, Firth of Clyde, Scotland. Hybrids were found to be common in both of the sampled populations. A full range of hybrid forms were observed and these tended to be distributed such that *F. spiralis*-like types were found closest to the *F. spiralis* zone, and *F. vesiculosus*-like plants were found closest to the *F. vesiculosus* zone. Neither shore appeared to be disturbed and so hybrids do appear able to compete with and become established amongst the parent species. It is suggested that failure to identify hybrids rather than their rarity is the most probable reason for the scarcity of references to them in the literature.

D. STRBAC*, M.A. RODRIGUES***, C.P. dos SANTOS** and D.O. HALL* (*King's College London, Division of Life Sciences, Campden Hill Road, London, W8 7AH UK. **Universidade Federal do Rio de Janeiro, Departamento de Bioquímica, Ilha do Fundão, Rio de Janeiro, Brazil)

Ultrastructure and photosynthetic activities in deep-sea *Laminaria abyssalis* (RJ, Brazil) and subtidal *L. digitata* (Scotland, UK).

Laminaria abyssalis (Phaeophyceae) which occurs in habitats at 40-100 m depth in the south-east Brazilian waters, is a potential source of phycocolloids and bioactive compounds. Since *L. abyssalis* was discovered (Joly and Oliveira, 1967) little has been reported on its physiology. In our studies a comparative analysis of ultrastructure and photosynthesis in deep-sea *L.*

abyssalis and subtidal *L. digitata* was conducted in order to understand their habitat adaptations.

Electron microscopy analysis showed that: 1) meristemic part of *L. abyssalis* was covered with a thicker layer of extracellular mucilages than *L. digitata*; 2) no epibionts were attached to the surface of *L. abyssalis*; 3) abundant physodes were present in cells of *L. abyssalis*, and 4) chloroplasts in *L. abyssalis* were smaller in size than in *L. digitata*.

The pigment content and O₂ evolution rate expressed per area unit were much lower in *L. abyssalis* than in *L. digitata*. Furthermore, the similarity in the chlorophyll *a/c* and chlorophyll *a/fucoanthin* ratios between the two species suggest that both species have similar photosynthetic unit size. The effect of photoinhibition on photosynthesis was determined using O₂ evolution rate and chlorophyll fluorescence parameters upon illumination. These measurements showed that *L. abyssalis* was more sensitive to high light intensities than *L. digitata*.

R. TAYLOR and R.L. FLETCHER (The Marine Laboratory, University of Portsmouth)

The effect of heavy metals on the brown alga *Sargassum muticum* (Yendo) Fensholt (Fucales, Phaeophyta).

The effect of heavy metals on the large, introduced brown alga *Sargassum muticum* (Yendo) Fensholt was determined using both field and laboratory culture studies.

Samples of primary laterals of *S. muticum* were collected from a range of localities in the mid south coast region of England, and the levels of Cu, Pb, Mn, Ni and Zn determined using Atomic Absorption Spectrophotometry. All algal samples showed only moderate bioaccumulation of the five metals studied, indicating the absence of serious contamination with these metals in the study areas.

Laboratory culture studies determined the effect of the above five metals on the growth of apical segments. Considerable variation in the sensitivity of the segments to the different metals was shown. Growth rates were reduced in the sequence Pb - Ni - Mn - Zn - Cu, whilst minimal lethal concentrations were as follows: > 1.0 ppm Cu; > 10.0 ppm Zn; > 15.0 ppm Ni; > 50.0 ppm Mn; > 50 ppm Pb. Comparative studies using embryonic sporophytes revealed the latter to be much more sensitive to the metals than vegetative segments.

A.J. TSAVALOS, M. HARKER and A.J. YOUNG (School of Biological & Earth Sciences, Liverpool John Moores University, Byrom Street, Liverpool, United Kingdom L3 3AF)

Pilot scale bioreactor production of carotenoids from microalgae for addition to animal feeds.

One of the biggest growth markets for microalgae could be as natural pigments, to help the fish industry's \$100 million per annum requirement for the ketocarotenoid, astaxanthin. Pilot scale studies employing HPLC and transmission electron microscopy into the production of astaxanthin via the pilot scale bioreactor fermentation of over 30 separate algal strains/species, have yielded encouraging results and are under further investigation. The pigment profiles of some of the most promising strains will be presented. The most successful alga observed so far is a selected strain of *Haematococcus* sp. which attains yields of 3g/L with 9% carotenoid/dry wt 96% of total carotenoid is ketocarotenoid composed of 31% astaxanthin bis esters, 37.4% astaxanthin monoesters, 22.1% adonirubin esters with other ketocarotenoids astaxanthin, adonirubin, canthaxanthin, echinenone totalling less than 5%. The post harvest stability of such carotenoids has also been studied in relation to harvesting methods and storage conditions. This has shown that by using a rapid grinding technique and storing at -25°C in a non-oxidative atmosphere (N₂), a stable product with a high astaxanthin content can be produced from ground algal cells without the addition of anti-oxidants thus avoiding any feed additive legislation, also shown is that intact algal cells can be stored at 5°C for long periods with little reduction in their potential pigmenting properties.

M-H. YANG, H. FANGLU, G. BLUNDEN and R.L. FLETCHER (School of Pharmacy & Biomedical Sciences and School of Biological Sciences, University of Portsmouth)

The effects of temperature, irradiance and salinity on the growth of juvenile forms of *Codium* species.

An unusual, juvenile, siphonous growth form of *Codium fragile* subspecies *tomentosoides* has been reported on support floats of marinas in the Solent area of Southern England. A study is now being made of British species of *Codium* in culture to determine whether they develop either as siphonous growths similar to those observed on

the floating platforms or as the characteristic erect forms seen when attached to natural substrata. So far *C. fragile* subspecies *tomentosoides*, *C. fragile* subspecies *atlanticum* and *C. adhaerans* have been studied. Different growth conditions (temperature, irradiance and salinity) have been used, but in all cases the three taxa grew as mats of siphonous filaments. Even after extended periods in culture, no sign of the formation of the typical erect form of the *Codium* thallus was observed. Conditions for optimum growth of *C. fragile* subspecies *tomentosoides* differed *atlanticum*. For example, temperature for the former was higher than for the latter.

FORTHCOMING MEETINGS.

BRITISH PHYTOPLANKTON DISCUSSION GROUP MEETING

19-21 April 1994, Southampton.

This meeting has been postponed to later in the year. There will be a notice in the next issue with the new date.

33rd NORTHEAST ALGAL SYMPOSIUM.

23-24th April 1994, Woods Hole, Massachusetts, USA

For further information, please contact:

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BPS SUMMER FIELD MEETING.

Seaweed Identification Course.

University College, Scarborough, North Yorkshire. 22-25th July 1994.

Course Organisers: Dr. F.G. Hardy and Mr. G.W. Scott (See page 9)

13th COLLOQUIA ASSOCIATION DES DIATOMISTES DE LANGUE FRANÇAISE

27th Septembre - 1^{er} Octobre 1994.

Location: Laboratoire Arago de Banyuls / mer. Included topics: Fragmentation and dissolution of diatoms (F. Straub); Typologie des sources (A. Cazaubon); Reconnaissance du vivant (M-J Chrétienneot-Dinet).

For further information, please contact:

C. Riaux-Gobin, Observatoire Oceanologique de Banyuls. CNRS URA 117, F-66650, Banyuls-sur-Mer, France. Tel: 68 88 00 40.

F. Straub, Laboratoire d'algologie, Gymnase cantonal, CH-2300 La Chaux-de-Fonds

MEETING OF BRITISH DIATOMISTS - OCTOBER 1994

Our Annual Weekend Meeting has been arranged for October 28th to 30th 1994, beginning on Friday evening and ending with Sunday lunch. The Venue is the YMCA National Centre at Lakeside, a modern and comfortable complex on the shore of the southern end Windermere.

This is an informal gathering of both professional and amateurs with various interests in diatoms, both marine and freshwater, living and fossil. The programme includes talks and poster displays together with opportunities for collecting material, some microscopy and much discussion. There will also be opportunity to visit Ferry House, home of the Institute of Freshwater Ecology and the Freshwater Biological Association.

For Further details contact Dr. E.Y. Haworth, Institute of Freshwater Ecology, Ferry House, Far Sawrey, Ambleside. Cumbria.

Deadline for Bookings: May 25th 1994.

BPS WINTER MEETING, 1995.

University of Portsmouth, 4-6th January 1995.

BPS WINTER MEETING, 1996.

University of Lancaster.

ISEP 11 - AUGUST 1996

The 11th biennial meeting of the International Society for Evolutionary Protistology (ISEP) will convene at the University of Cologne (Cologne, Germany) from August 9-13, 1996. The meeting will be held in conjunction with the 1st European Phycological Congress (August 11-18, 1996).

The primary purpose of ISEP is to provide an exchange of scientific knowledge between protistologists who work in the fields traditionally known as protozoology, phycology and mycology. The scientific program will include general lectures, several symposia, contributed papers and workshops.

For further information, please contact:

Prof Michael Melkonian, Universität zu Köln, Botanisches Institut, Gyrhofstraße 15, D-50931. Köln.

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1ST EUROPEAN PHYCOLOGICAL CONGRESS.

This international meeting will be held in Cologne, Germany from 11-18 August 1996. It will provide a forum for phycologists (young and established) from all over Europe and overseas for communication and discussion on all aspects of phycology: basic and applied; freshwater and marine; organismic and molecular.

The scientific program will include several plenary and special lectures, symposia, contributed papers, posters, workshops and excursions.

For further information, please contact:

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The Society of General Microbiology has sent the Society a listings of thier meetings for the rest of 1994 and I have included those that I think members may be interested in.

If you require further information for SGM meetings contact: Jill Seegers, SGM, Marlborough House, Basingstoke Road, Spencers Wood, Reading, RG7 1AE. Tel: 0734 885577. Fax: 0734 885656

12th April, 1994. Dublin. Microbial Food Hazards.

4-6th July, 1994. Brighton. UK Biotechnology '94 including SGM supported Conference on Fermentation Physiology.

3-8th July, 1994. Prague. IUMS International Congresses of Bacteriology and Applied Microbiology and Mycology.

7-10th September, 1994. Canterbury. RNA polymerase and its effectors in prokaryotes and eukaryotes.

10-12th September, 1994. Noordwijkerhout, Netherlands. 129th Ordinary Meeting.

This meeting includes some groups which may be of interest to Phycologists.

Environmental Microbiology: (The impact of man on the microbiology of the North Sea),

Fermentation and Bioprocessing: (Anaerobic digestion).

If you know of any meeting, no matter how big, and think British Phycologists would be interested in please write and tell me.



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