

The Phycologist

The Newsletter of the British Phycological Society

Editor: Dr Amanda Burson

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AGM
minutes

Diatoms of Britain
update

(Re)considerations
on HAB toxins

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2023

British Phycological Society

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Happy spring issue 2023! In this issue we are starting to see the fruits of labour from several projects (co)funded by the BPS. It's lovely to see people getting back out into the field and producing new understandings in phycology. It was also lovely to see people in person again at the 71st BPS Meeting in Newcastle! I think we all enjoyed reconnecting and there were, as usual, some fantastic and engaging presentations. Well done to all of the presenters, both oral and posters; I for one learned something new every day. For those that couldn't make the meeting the abstracts are included to pique your interest. The AGM minutes are included as well so you can see what the council has been doing on your behalf. As always, keep sending me your ideas, reports and notices!

Very best,
Amanda Burson

Remember - do keep sending in your contributions. Write to us with your phycological views, news, work events, or any matter you wish to share with readers of The Phycologist. YOUR input is required; all relevant material will be considered (job adverts, science reports, book reviews, news items of topical interest, meeting announcements, research news, and suggestions for future articles are always welcome). Without YOU the newsletter would not exist.

As a reminder, previous issues of *The Phycologist* can be downloaded at <https://brphycsoc.org/the-phycologist-back-issues/>

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Syndromic surveillance: increasing the recognition of cyanobacterial and cyanotoxin health impacts

Submitted by: Geoffrey A. Codd

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It has long been recognised that Koch's Postulates, the classical epidemiological criteria used in assigning human illness to a specific microorganism, cannot be applied to cyanobacteria and their toxins as causative agents (e.g. Hunter, 1994). Furthermore, the nine epidemiological criteria of Bradford-Hill (B-H): (i) strength of association; (ii) consistency; (iii) specificity of association; (iv) temporality; (v) biological gradient; (vi) plausibility; (vii) coherence; (viii) experiment; and (ix) analogy, can be used, but to only to a limited extent (Hunter, 1994). However, even including the use of modern methods of cyanotoxin analysis and the increasing recognition of exposure routes and exposure media (Codd et al., 2020), the applicability of the B-H criteria continues to be limited by e.g the lack of recognition of cyanobacterial mass populations, inadequate details of exposure scenarios and incomplete post-event investigations and reporting. Although the increasing roles of molecular studies, including epigenetics, biomarkers, genomics, genotoxicology and meta-analysis, in supporting the use of the B-H criteria are recognised (Fedak et al. 2015), uncertainty also continues on the value of the nine criteria in distinguishing between causation and association. Whilst the ability of cyanobacteria and cyanotoxins to present health risks and to have exerted harmful effects on humans and animals is well established (Codd et al., 2020; Chorus and Bartram, 2021), absolute case numbers and their corresponding distribution are unknown.

Syndromic surveillance may offer an additional approach to localising and quantifying human illness cases which may be associated with harmful algal and cyanobacterial blooms. This procedure, established in the 1990s to detect pre-diagnostic (i.e. before diagnoses are confirmed) signs and symptoms of disease, is now in daily use in the health care and public health sectors to help to identify potential public health incidents of concern (e.g. Yoon et al., 2017; including in the UK (e.g. UK Health Security Agency, 2022). With reference to waterborne disease, Berger et al. (2006) recognised the potential value of syndromic surveillance in providing timeliness, establishing baseline disease burdens, identifying geographical sites and incident extents, and increasing response capacity. However, these authors cautioned against reliance upon syndromic surveillance as a main outbreak detection method in place of traditional disease surveillance methods.

Lavery et al. (2021) of the US Centers for Disease Control have reported on the potential of syndromic surveillance for estimating the prevalence of exposure to harmful algal and cyanobacterial blooms, versus negative health outcomes in a study from 2017 to 2019. This follows the "One Health Harmful Algal Bloom System" survey carried out in 18 US States via which information was collected on about 389 cases of human illness and over 400 animal illness cases associated with harmful algal and cyanobacterial bloom events in 2016-

2018 (Roberts et al., 2020). In the more recent study (Lavery et al. 2021), the percentages of healthcare US Emergency Department (ED) visits associated with exposure to blooms increased during the warmer months when blooms also increase, with exposure routes having included inhalation, ingestion and skin contact. The 321 harmful bloom-associated ED visits recorded throughout the 2017-2019 study occurred in 10 Regions of the US Department of Health & Human Services, with neurological, gastrointestinal, respiratory and dermatological syndrome categories being reported. With acknowledged limitations (Lavery et al., 2021), this ED visit study has provided a further example of the potential contribution of syndromic surveillance in identifying the extent of exposure to harmful algal and cyanobacterial blooms and associated health effects. Syndromic surveillance may thereby contribute to the overall risk management of cyanobacterial blooms, alongside the continuing need for improved bloom recognition and reporting among waterbody-users and -consumers.

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Review of 71st British Phycological Society Winter Meeting 2023

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Rebecca (left) and Riddhi (right) standing in front of the posters they presented during the meeting.

This year marked the 71st annual meeting of the British Phycological Conference, held in Newcastle-upon-Tyne from 24th-27th January 2023. This event was curated by the extremely helpful team of 'blue shirts' from the Dove Marine Laboratory of Newcastle University, with all organisational efforts headed by Professor Pip Moore.

Tuesday 24th January was a day for arrival, registration and submission of posters and talks. A reception event with welcome drinks allowed for initial meetings and catch-ups, and the acquisition of a stylish, reusable travel mug for use throughout the duration of the conference. This was followed by another opportunity to socialise over drinks at the local Hancock Pub.

Wednesday 25th January marked the first full day of the conference, with opening welcome statements being made locally from Prof. Pip Moore, and the overseas address given by Prof. Juliet Brodie on behalf of Prof. Lin Le Gall.

The topic for the day was Phycology in a Changing World and Citizen Science, with several talks being Manton Prize Assessed. Sessions were chaired by Francis Bunker, Martyn Kelly and Zoe Morrall. There was a diverse range of presentations encompassing (but not limited to) the removal of algal mats (Zoe Morrall), habitat provisioning by a UK sugar kelp farms (Sophie Corrigan), and the best practices for co-created citizen science with a thought-provoking approach on engaging different community groups in projects (Heather Sugden). The day concluded with the BPS AGM, and the poster session held in the Dove Marine Laboratory. Lively discussions served with a side of fish and chips made for an enjoyable evening for all. Both of us were afforded with the opportunity to pre-

sent at this session, sharing our work on seaweed polyphenols and their applications in the animal feed industry.

Thursday 24th January had talks themed on Biotechnology and General Phycology, with sessions being chaired by Tom Fairchild, Gary Caldwell, and Jason Hall-Spencer. Talks were diverse, with a few examples being the blue carbon potential of kelp forests (Pip Moore) and green seaweed mat dynamics (Annesia Lamb). A fascinating plenary was given by Jessica Adams taking a technological processing approach through steam explosion of green macroalgae. This was a very different kind of talk, with the focus shifting from a biological approach to that of a technical processing one, bringing a fresh perspective to the day that we as interdisciplinary researchers appreciated.

The evening brought around the public lecture given by Juliet Brodie on The Big Seaweed Search: citizen power and scientific research, particular interest was paid to different sampling techniques and how to become involved in on-going projects. This was followed by the conference dinner held at the Baltic. This evening was a highlight of the conference, with excellent food, city views and conversations. At this event, the Manton prize awards for best oral and poster presentation were awarded. With best oral presentation being allocated to Hannah Kemp for her entertaining talk Experimental effects of light and temperature on the growth and formation of blanket weed blooms at the mesocosm scale. Winner of the best poster was awarded to Johanna Winder for her visually engaging and well discussed work on The ice-binding proteins of *Fragilariopsis cylindrus*: a computational exploration of genetic, structural, and evolutionary features.

The final day of the conference began with an insightful and amusing Sci Art themed presentation on algal inks, with Phoebe Lewis discussing her journey from a homemade approach at extracting pigments during lockdown to the vast collection of colours now extracted in the lab setting. The conference was brought to a close by Prof. Jane Lewis. Overall, the week was enjoyable, bringing about a sense of community and support, with an excitable atmosphere for being able to regroup post COVID-19. The week provided excellent opportunities for networking and making connections, with questions and discussions helping to motivate and inspire researchers. This was our first experience of a British Phycological Society meeting, and we look forward to attending again in the future.

71st Annual General Meeting

Newcastle University

17:00 to 18:00 Wednesday 25th January 2022

1. Meeting Agenda & Minutes

Meeting chaired by the President, Jane Lewis

2. Apologies for absence

Geoff Codd, John Griffin, Anne Jungblut, Nicky Slee, Line Le Gall, Jason Hall-Spencer, Gill Malin

3. Announcements

a) Members present were asked to sign their names. A total of 39 members were present creating a quorum for the AGM. (The constitution states that 30 members of the society must be present to create a quorum).

b) Approval of the Minutes of the 70th AGM, 5th January 2021 Swansea University.

Proposal to accept the minutes as an accurate record: Pippa Moore, seconded Wytze Stam

4. Matters arising

No matters arising were raised.

5. Membership proposal to include an option for on-line journal access

The proposal was read to the AGM by Jane Lewis

Proposal to accept this new membership option was made by Suzi Arnot and seconded by Hilary Redden

6. Reports from Elected Officers (*full reports are available at <https://brphycsoc.org/annual-general-meeting/> as versions printed here are abridged*)

a) Secretary (Francis Bunker)

Francis Bunker delivered the Secretary's report:

Over 2022 I have answered various queries from members and the public or passed them on to the relevant Council / sub-committee members. These have been many and varied correspondence from people wanted to reach the British Psychological Society. When correspondence has arrived relating to events which are of potential interest to BPS members, I have notified our Webmaster Andy Davies and his assistant Sally Archer-Thomson so notices can be posted on the BPS web site.

Council meeting minutes and the BPS Operating Manual are now stored on the web site. There have been updates to this manual in 2022.

A notice advertising Council positions was drafted and sent to the *Phycologist* for publication in the autumn issue. Unfortunately, due to a misunderstanding, an election for an ordinary member of council was not held.

The BPS Insurance was renewed at the end of November 2022 with Self Assured Underwriting Agencies Ltd.

b) Treasurer (Nicky Slee)

Jane Lewis delivered the Treasurer's report to the AGM on behalf of Nicky Slee:

The YE2022 accounts have been prepared by the Treasurer and independently examined by Paul Murray of LM Griffiths & Co. Ltd (23th January 2023) and are attached. This is in accordance with decisions at the last Winter council meeting and BSP AGM. The Council meeting members, as Trustees have been asked to approve these at the council meeting on 24 January 2023. statements for the British Phycological Society (Charity Number 246707) will be submitted to the Charity Commission Website (CCW) on time (by 31.1.2023).

The AGM Members at the AGM are asked to approve:

1. Acceptance of the Prepared Accounts by members of BPS attending the AGM approve the accounts, then the YE2022 can be uploaded to CCW.

2. To elect Paul Murray of LM Griffiths & Co. Ltd as the Independent Examiners for the BPS YE accounts for YE2023.

Updates:

MOU for Algaebase is in place and we have an annual liability of £3000, plus £35 associated bank costs. This agreement is in place from 1st September 2022 until July 2025. We encourage members to use this facility.

Account updates:

The BPS has three accounts with the Bank of Scotland:

i. A current account with online access that has been successfully used by the current treasurer to carry out the necessary payments.

ii. Another online account with a small balance in.

iii. A BoS Savings account. This BPS account has been in M Tobin's name since she was Treasurer. The BPS Council has tried since then (2016) to get the signatory transferred to the next Treasurer(s). Many forms have been completed and sent to the bank. The account needed to be activated before any forms would be reviewed by the bank and BPS contact email have now been updated. The signatories have finally been transferred to Treasurer and new signatories for BoS have been approved and the account has now been activated after further checks. Statements are now being sent to Treasurer's address (Essex). A complaint procedure enabled this to be finalised and the BPS were initially offered £150 once everything had been resolved, but due to further issues and delays this was increased to £500. This money was received into the account in the Autumn. Next step is to get this with online access.

Accounts Overview:

BoS Current account: £81995.54 (Balance on 22.1.2023)

Bos Linked current account: £27.61 (Balance on 22.1.2023)

BPS BUS ac (Savings account) £38166.54 (Balance on 9.1.2023)

NSI Accounts: £98097.97 (Balance on 1.1.2022)

Total: £218,287.66 (Total on 22.1.2023)

Awards Allocated and other liabilities but money still in BoS Current account: £63,732.08

Money available after allocated money accounted for: £154,555.58. In additions there are some governance costs (amount to be determined).

Proposal to accept the accounts for year ending 2022 was made by Francis Bunker and seconded by Saul Purton.

The proposal that LM Griffiths should be asked to produce the BPS accounts for the year ending 2023 was made by Amanda Burson and seconded by Hilary Redden.

Council thanked Nicky Slee for her hard work for BPS during the last year.

c) Membership Secretary (Hilary Redden)

Hilary Redden delivered the Membership Secretary's report:

Members should remember to keep a copy of the emailed receipt of payment if they need to use it for personal reimbursement or for use in annual job reviews as proof of continuing personal development.

There are 41 countries where members have trouble paying via PayPal and the council is exploring payment op-

tions to increase our international membership.

On 22 January 2023, the active membership of the Society was 499. This includes our current 12 Honorary Life Members. It is 6 more than January 2022. Student membership has risen slightly from 32 to 33% but considering the disruptions to teaching over the last few years this has held up well. Members receiving a physical copy of the EJP by post were 26%. This percentage is held up by other categories as the EJP by post % in the ordinary membership-with-journal category has dropped from 20 to 17% since 2019.

d) Student Representatives (Hannah Thomas)

Hannah Thomas delivered the Student Representative's report:

As student representative a major part of my role is disseminating information through the Society's social media pages. Currently, approximately 2 posts a week are being circulated using Twitter including reposts or other people's tweets however enhancing this to a minimum of 3-4 posts per week will improve awareness of the Society and hopefully encourage new members to join. The addition of an outreach and engagement officer will help maintain this higher level of posting and hopefully also diversify the type of posts that we are disseminating. At the moment, the predominant posts are regarding deadlines/conferences or reposts. Ideally, we would be posting more about recent discoveries and publications. I have also been looking for other outreach opportunities and have attached a good resource with a list of smaller science festivals and events which might be worth attending. This is to be discussed with committee members on the outreach committee. I am looking for a new student to join to ensure that there is someone to learn the role and take over in 2024.

e) Joint Editors in Chief of the *European Journal of Phycology* (Christine Maggs and Juliet Brodie)

Christine Maggs and Juliet Brodie delivered their report and one on behalf of John Beardall (see below):

Christine Maggs and Juliet Brodie have continued as joint Editors in Chief, with Kate Schoenrock-Rossiter as Editorial Assistant. We have two new Associate Editors, Mahasweta Saha (PML) and Jessica Adams (Aberystwyth). The Journals' Management Committee last met on 4 May 2022 (reported at Summer Council). Hennie Thomson left her position as our Portfolio Manager on 21st December 2022; until she's replaced our contact is the Global Head of Portfolio, Jason Wilde.

In the last 12 months we have had 85 new submissions to the journal, 13 of which were reviews. This is a slight decrease from the previous year (91 new submissions) but an increase in reviews (from 10). Countries with the highest numbers of submissions are Brazil, India, China,

Israel and Japan (similar to last year).

f) Hon Editor in Chief *Applied Phycology* (John Beardall)

The editorial team continues as John Beardall as Editor in Chief with Juliet Brodie and Chris Maggs (Managing Editors), supported by Kate Schoenrock-Rossiter as Editorial Assistant.

In September 2022, *Applied Phycology* passed the assessment to be accepted into the Scopus database, and an Editorial Board meeting was held online to discuss the journal.

The two "special issues" were published (but apparently without the introductory editorials):

Towards a global view of algal molecular ecology

Created 15 Sep 2022 | Last updated 15 Sep 2022

Edited by Dr. Richard G. Dorrell, Dr. Flora Vincent and Dr. Deo Florence L. Onda

Applied Phycology for Sustainable Development (on SDGs, led by John Beardall)

Created 14 Jul 2022 | Last updated 17 Nov 2022

Edited by Prof John Beardall, Prof Christine Maggs and Prof Juliet Brodie

How these are listed online has been a concern and we have had to compromise on what a "special issue" means – we do not have much flexibility with this type of publishing. They are now called "collections". They have considerably improved the flow of mss to the journal. Now, Volume 3 ("2022", 445 pp!!) has been published on the website with 10 papers plus retrospectively the "special collection" on culture collections (8 papers) as well as *Applied Phycology for Sustainable Development/SDGs* (9 papers including 3 reviews). However, Downloading the Special Collection on SDGs produces this set of 9 pdfs but without the introduction to the Collection by John! In fact John's introduction to the Collection doesn't seem to be on the website either.

The new process will be that T&F can still create an option for authors to submit to a dedicated special collection in the submission platform so it shouldn't affect that process at all. Papers will all go into the main issue, and then can be collected into a themed area with the landing page and summary. Having e-location rather than page numbers is better as there aren't a group of papers with all different pagination together in a collection.

g) Editor of *The Phycologist* (Amanda Burson)

Amanda Burson delivered the Editor of *The Phycologist* report:

Thank you to all the contributors to *The Phycologist* to date. To help facilitate BPS funding award related contributions I have created a "check-list" for the various submission types (ie. travel bursary report; student project report etc). These will usually be attached to the email letting recipients know they have been successful in obtaining funding but can be requested and/or clarified by emailing editor_phycologist@brphycsoc.org. While all of the items on the checklist are required, the points for the body of the report are intended as a suggested guideline rather than strict criteria and variations will be considered.

h) Webmaster (Andy Davies)

Andy Davies delivered the Webmaster report:

Once again we have maintained the functionality of the site through the annual renewal process and the entire year with over 99% uptime. The largest change this year was an automated email that was sent to every current member in late 2022 reminding of the impending Jan 1st renewal. I felt this was a huge success, it cut down on unwanted and failed renewals (due to payment details changing) and as such very few members cancelled their membership after Jan 1st. Several members did fail to renew and have not responded to personal communications, as such are deemed to have lapsed. In other news, we overhauled the Awards submission portal to a more reliable software and this too seems to have been a success. Visitor numbers continue to look good, with excellent visitation rates during the Hilda Canter Lund submission and voting phases.

BPS algal records continues to function and I spend some time maintaining the site throughout the year. However, I have not focussed on any improvements. The committee and the wider membership should discuss how best to revitalize this resource.

7. Elections and Council Vacancies (Francis Bunker)

Council vacancies for 2023 were advertised in the autumn issue of *The Phycologist* and an election became necessary. Unfortunately, the deadline for elections wasn't met so it proposed to co-opt two new members, John Griffin and Mahasweta Saha onto Council until elections can be arranged for the 2024 AGM.

Proposal to co-opt these two persons to Council was made by Christine Maggs and seconded by Jessica Adams.

A vote of thanks was given to the following for the work they have done for the society whilst serving on Council:

Geoff Codd for his sterling work over 24 years on Coun-

cil as BPS President (2007 – 2009) and as FEPS Representative for 15 years.

Dan Franklin (Ordinary Council Member), who has served his first term on Council.

8. Hilda Canter-Lund Prize (Martyn Kelly)

Images for the 2022 photography competition can be seen at <https://brphycsoc.org/canter-lund-2022/>

9. Subcommittee reports (*full reports are available at <https://brphycsoc.org/annual-general-meeting/> as versions printed here are abridged*)

a) Awards and Training Committee (Chair: Jason Hall-Spencer)

Jane Lewis delivered the report on behalf of Jason Hall-Spencer:

The A&T Committee oversees the BPS bursaries and awards programmes. It is Chaired by the Immediate-Past President. All the current BPS Council Ordinary Members help to judge applications (3 plus Chair look at each round of applications). So far in financial year 2022-2023, thirty-five applications were successful, totalling £42,037 of the nominal budget of £60,000. Awardees were from both the UK and overseas, reflecting the international composition of our membership. Two new schemes, a COVID recovery scheme, and an Algae-Video bursary scheme ran in December 2021. The Algal-video scheme has continued in 2022. Council agreed to increase the value of Project and Conference Bursary awards in 2022 to reflect increased costs and to increase the attractiveness of our awards. Equal opportunities monitoring for Awards and Training applications was adopted in 2021. The majority of applicants (and awardees) self-identified as white, heterosexual, and female, but there was some diversity in our application pool. Success rates for applicants was around 80% with no differences in success rate between applicants identifying as male or female. The Society will continue to collect these EO data over future rounds.

b) Biodiversity and Conservation Committee (Chair: Martin Wilkinson)

Martin Wilkinson delivered his report to the AGM:

It is hoped that there may be another freshwater identification course at FBA about June 2023. The broader need for more freshwater identification courses both amateur and professional is being considered. There is a need for charophyte identification training.

Seaweed identification course, Plymouth, 17-19 May 2023. Details from Francis Bunker. Seaweed field meeting, St Andrews, 1 to 6 August 2023, Details from Martin Wilkinson. It is hoped to link this course with citizen science efforts in Scotland.

Brown seaweed book now expected to be released April 2023. New Danish seaweed flora, of which Juliet Brodie co-author, very useful for some British flora, has an English language edition, Seaweeds of Denmark vols 1 & 2. European charophyte flora expected publication summer 2023. British freshwater flora 2nd edition, BPS supported publication, has DVD illustrations moved online and has online taxonomic updates since its release in August 2021.

Desmid posters almost sold out. Possible update, republication or online transfer being considered.

Diatom flora project, funded by BPS, joint with National Museum of Wales has proceeded well and a next stage is being considered.

Seaweed red data list submitted in 2021 showed us problems with IUCN requirements based on higher land plants. Problems and possible solutions are in paper published by Juliet Brodie et al. We are discussing how suitable sampling programmes could be introduced to help in future.

Big Seaweed Search devised by Juliet Brodie and NHM is particularly good citizenscience project, now 13 years old, and linked to Marine Conservation Society and used as basis for new schemes overseas. Juliet will present proposal to Council for formal BPS partnership.

Algal recording site problems resolved but we are considering whether BPS should have a data officer linked with it.

Scottish Biodiversity plan to Scottish Government concerns about biodiversity loss does not have an algal component. This may be because it is considered already covered by NatureScot citizen science marine monitoring programme started two years ago. We are investigating this and if BPS can help.

c) Algal Outreach Committee (Martyn Kelly, Chair)

No report given.

d) Algal Applications Committee (Gill Malin)

Saul Purton delivered the report on behalf of Gill Malin (Note that date on report says Jan 2022 in error):

The remit of the Algal Applications Committee covers all aspects of applied phycology from biotechnology through to the use of algae as bioindicators and the production of algal biomass for inter alia biofuels, food, feed, nutritional supplements, and various high value products.

The general subject area of Applied Phycology seems to be continuing to gain momentum – the programme for the BPS annual meeting reflects this very well with sessions on Sustainable Food Systems and Blue Carbon. BPS welcomes Corporate Members and information can be

found on the website <https://brphycsoc.org/corporate-membership/>. The BPS membership also benefits from Annual Meeting support kindly provided by various algae-related businesses e.g. this meeting has had support from Barti, Membranology (a spin out company of Swansea University), VariconAqua, and the BBSRC network AlgaeUK, and Taylor & Francis who publish the BPS journals. We thank them all for their support!

Given that the overall aim is to foster stronger connections between the BPS and the commercial companies, public agencies and regulatory bodies that use or consider algae in their work, we welcome your ideas and suggestions for working together at any time. For example this could range from a suggestion for a special session at a future BPS Annual Meeting, a one-off meeting focussed on an applied phycology topic or an event that would inspire and help with the training of the next generation of applied phycologists from amongst the BPS Student Membership.

Saul Purton added that CCAP and AlgaeUK would like links to the BPS web site. Also, that the HSE want to understand seaweed farming and would like the BPS to be involved.

10. Federation Reports (*full reports are available at <https://brphycsoc.org/annual-general-meeting/> as versions printed here are abridged*)

a) Federation of European Phycological Societies (FEPS)

No report produced. Geoff Codd retired in July and Jason Hall-Spencer is not taking on the role until 2023.

b) Federation of European Microbiological Societies (FEMS) (Anne Jungblut)

Jane Lewis read the report to the AGM:

FEMS council meeting and AGM will be held as virtual meeting on September 2022, and FEMS is offering several Meeting Organizer Grant and an Early Career Meeting Attendance Grants as well as Early Career Project Grant: https://fems-microbiology.org/about_fems/network-and-activities/grants/. FEMS is seeking input by Early Career Researchers for the creation of professional development resources. BPS will hold holding a special session at the 9th Congress of European Microbiologists conference, Hamburg, 11-15 July 2023 in Hamburg, Germany. The title of the session is "Diversity and ecology of aquatic phototrophic biofilms revealed interdisciplinary approaches and modern 'omics techniques" (<https://www.fems2023.org/programme>).

c) Royal Society of Biology (Jane Lewis)

No written report produced but Jane Lewis reminded the AGM that there was a reduced membership price to the RSB for BPS members and that membership gave good opportunities for Continuing Professional Development (CPD). Also noted how the RSB feeds into government consultations.

11. Future Annual meetings

Reading University, January 2023

Jane Lewis thanked Council and the Sub-Committees for their work in 2022.

Meeting end 17:54



Travel Bursary Reports

Harnessing the Power of Algal Biotechnology: A Journey from South Africa to London and Back Again

Submitted by: Ms Julianie Stapelberg

University College London; Julanie.stapelberg.19@ucl.ac.uk



The sun beamed down on a small coastal village of Arniston in the Western Cape, South Africa as I joined the crowd of delegates, all eager to learn more about the current state of the algal sector. We had all arrived for the 33rd Congress of the Phycological So-

ciety of Southern Africa (PSSA). I was especially excited for this event since it had been five years since I had left my home country of South Africa to pursue my PhD in algal biotechnology at University College London (UCL).

The first day of the congress kicked off with a few ice breakers around the pool, followed by the film premier of *Kelp: South Africa's Golden Forests*. It is a short film that showcases the beauty of the Southern African kelp forests and the emotional connection that the local communities, industry, chefs, environmentalists, and scientists have for these macroalgae. After the film, we had a Q&A with the producer, setting the tone for the rest of the week.

The next day began with a traditional morning walk around the perimeter of the venue and breakfast. We were then honoured to hear the address of the PSSA President Mark Rothman, followed by keynote lectures by Prof Ernst Baard from CapeNature, and Professor Alan Critchley with "Seaweeds: Myths, legends and BS (i.e., biostimulants and

other multifarious applications)!". We then had a series of talks during the day which included taxonomy, new discoveries, and the aquaculture industry, ending with a Bio-Smart Scientific-sponsored dinner.

On Wednesday, after some one-on-one meetings and conference productivity, we rewarded ourselves by travelling to a nearby town and seeing giant sting rays. As true phycologists, groups also went to sample kelp, diatoms and other algae along the coast and this led to more extended spontaneous excursions. There was news of a secret cave only accessible from a smaller cave at low spring tide, so naturally, we explored it! Following a good night's rest, I was excited for my favourite day - Thursday - when I was to give my presentation in the first slot of the "Biotechnology" session. My talk was titled "Should Southern Africa Invest in Algal Biotechnology?".

I started my talk by explaining my journey from South Africa to London, where I have acquired the synthetic





biology tools and techniques for genetic engineering of *Chlamydomonas reinhardtii* as a light-driven cellular factory for expressing high-value recombinant proteins. The audience was highly engaged as we discussed the possibilities of microalgal biotechnology and how it could be used in South Africa. We talked about the potential of using this technology to produce vitamin-enriched food, oral vaccines or growth hormones, and endolysins to reduce antibiotics in agriculture. We also discussed the advantages of South Africa, such as its ample space, natural growing conditions and accessible resources, and how it could be used to create job opportunities. At the end of my talk, we discussed the potential of collaboration to sustainably combat climate change, and the audience left the conversation with the thought that "Why shouldn't Southern Africa invest in Algal Biotechnology?". This discussion continued throughout the rest of the day with other delegates and presenters.

The congress ended with a banquet and prize-giving, and I was ecstatic to be awarded the best student presentation prize. I am incredibly thankful to all the organisers of PSSA, as well as the BPS (award #2022_BPS_0183) and the Biochemical Society for funding the trip. This congress was truly an eye-opening experience for me, not just in terms of

learning what is currently being researched, but also in terms of the potential for collaboration and working together towards a better future. It was great to reconnect with the scientists from my home country, and I am looking forward to more collaborative conversations aiming to improve the global bioeconomy.

Photo credits to Prof Gavin Maneveldt.



British Phycological Society winter meeting in Newcastle

Submitted by: Mollie Allerton

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Newcastle University, BPS conference venue



Presenting at the BPS annual winter meeting (photo credit: Johanna Winder).

I travelled to Newcastle for the 71st British Phycological Society winter meeting, 24th-27th January 2023.

I was presenting a part of my PhD work, titled 'Exploring changes in estuarine and coastal phytoplankton communities.' This work looks at how phytoplankton communities are responding to changing environmental conditions, how these changes can be used as indicators of different drivers, and how estuarine and coastal environments can be best managed.

My presentation was on day 2 of the conference, alongside other talks on 'phycology in a changing world', and 'citizen science'. Since my PhD started during a global pandemic, I haven't had the chance to present at an 'in-person' conference before. The British Phycological Society meeting was a very welcoming environment for a first presentation, and I had people ask me questions which made me think about my work from angles I hadn't considered before.

Watching presentations in the other sessions from people further ahead in projects like my own gave me ideas and information for my work. I had been thinking about the logistics of a mesocosm experiment, and listening to Hannah Kemp's talk, 'Experimental effects of light and temperature on the growth and formation of blanket weed blooms at the mesocosm scale' was a great insight into how this might be able to happen!

The conference dinner on day 3 was held at the BALTIC centre for contemporary art. The walk to the venue was great for seeing the city as it was getting dark, and there were fantastic views from the Six viewing box where the meal was held.

The conference dinner was a great opportunity for socialising and getting to speak to people I hadn't had the chance

to before. I was able to ask the people I was sat with more about their posters, their talks, and their work. I was sat with someone who was able to tell me about how the experiments I had been thinking about are best planned, the best way to go about finding somewhere I might be able to carry it out, and who I should contact. Many thanks to the British Phycological Society for funding my trip to Newcastle (2022_BPS_0175) and giving me the opportunity to present at my first 'in-person' conference. Watching talks about research in similar areas and being able to socialise and ask people about their work has given me ideas for things I can implement into my own research and has been immensely helpful! I would not have been able to have gained the experience and ideas that I did without the help of the BPS award.



Walking to the BPS conference dinner at the BALTIC centre for contemporary art.

British Phycological Society Annual Meeting

Submitted by: Eric Harris-Scott

Blue marine foundation

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Former Research Associate on the RaNTran Project at the University of Portsmouth



With the support of the British Phycology Society through their Early Career Researcher travel grants (Award number: 2022_BPS_0173) I was able to attend the British Phycology Society Annual meeting 2023 hosted in Newcastle. I presented work from the RaNTrans (Rapid reduction of Nutrients in Transitional waters) project which is part of the Interreg funded research programmes. The RaNTrans project aims to develop and test innovative and cost-effective methods of rapidly reducing algal mat coverage and contribute to reductions in nutrient levels in coastal and transitional waters. Therefore, the British Phycological Society Annual meeting provided a great platform to showcase a range of work from across the RaNTrans project. My colleague Dr Annesia Lamb, University of Bournemouth, presented work regarding Green Seaweed Mat Dynamics in The Channel Region, Genetic Identification, Abundance, and Seasonal Nitrogen Storage. Whilst my colleague from the University of Portsmouth, Zoe



Morrall, presented on whether mechanically removing algal mats offers a suitable remediation method to improve coastal water quality and reduce nutrient pollution.

The RaNTrans project comprises nine partners from across the UK and France, with the lead partner being University of Portsmouth. I had the chance to present some research undertaken by Stephanie Lemesle and the RaNTrans partners at University of Caen in France, on the ability of sugar kelp (*Saccharina latissima*), dulse (*Palmaria palmata*) and green algal mat (*Ulva* spp.) to absorb nitrogen over time at different initial concentrations. Further to this I also highlighted some of the RaNTrans project's upcoming kelp trials which are being continued by the University of Portsmouth. This research is using sugar kelp *Saccharina latissima* propagated on twine by the Scottish Association of Marine Sciences, then grown on rope lines at University of Portsmouth's Institute of Marine Sciences research raft in Langstone Harbour in the Solent. Here the RaNTrans project will assess the in situ nitrogen remediation capability of the sugar kelp, as well as monitoring the epibiont community.

The other research presented at the meeting was incredibly varied and the

passion of the phycological community was on full display. I was fascinated by the presentation from Professor Gary Cauldwell on the development of living paints utilising algal cells to create long-standing and environmentally safe paints, the meeting really opened my eyes to algal species' myriad uses. The multiple presentations on pigment extractions has also sparked a new personal interest for me and I will be setting up the bath tub at home for some homemade extractions to use in my own artwork.

In between the jam-packed meeting schedule each day I took the chance to explore Newcastle city centre as this was my first time visiting although it will certainly not be the last! Of all the historic landmarks the city has to offer it was Newcastle Castle that took up the most of my time, as an ancient history enthusiast I was drawn in by the Castle's Roman origins and varied uses over the years since. Another aspect of the city I really enjoyed is the architecture and how it has kept lots of features from the industrial revolution period which I soaked in with a visit to the Discovery Museum, a beautifully ornate building with Grade 2 listing and home to a huge selection of model boats and the first steam powered boat, Turbinia. All I really found out though, is that I need a second visit!



Sneaking seagrass into the mix - seagrass algal assemblages

Submitted by: Emma A Ward
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Presenting my talk on seagrass algal assemblages, specifically focused on intertidal seagrass and green algal matt off in the Solent, UK. (Photos © Hannah Earp).

As an MRes student, the 70th British Phycological Society Annual General Meeting was a fantastic introduction into the world of scientific conferences. I was welcomed to the society during the informal ice breaker where I was immediately put at ease. Despite my research focussing on seagrass, I quickly found common ground with other members early in their scientific careers.

The gather town environment was an excellent substitute to the in-person aspect of the conference and maximised interactions. I have suggested the interface be used within my university for online activities. I found the wide

range of talks engaging and interesting to find out about the latest developments in research. I particularly benefited from watching the presentation techniques, and how the science was being presented and communicated to an audience. I look forward to using the approaches and styles used and applying them to my own scientific communication. The Blue Carbon and Kelp Ecology session broadened my knowledge of the movement of carbon through other marine habitats.

I presented a poster based on my research for my MRes course entitled "Assessing the Blue Carbon Potential of Seagrass Restoration in the UK". I spoke

about my progress within the Solent Seagrass Restoration Project, where 21,000 *Zostera noltii* seeds have been planted in a degraded intertidal mudflat in Farlington Marshes. The seeds were rotted from existing blades sourced locally and processed at the Institute of Marine Sciences, Portsmouth. The processed seeds were bagged in degradable Hessian and deployed in December 2021 at two sites. These restoration sites will be monitored in Spring and Summer to assess growth. With the aim of successful restoration, the carbon capture potential of the developing seagrass will be assessed during summer 2022. I will then investigate the applications of this potential in climate change mitigation. I enjoyed discussing my research with like-minded people who shared an interest and drew parallels with algal blue carbon. The online poster session provided me with a great introduction to presenting at conferences and building confidence.

I am grateful for the generosity of the British Phycological Society for awarding me a grant to attend the BPS Annual meeting. I hope to attend the 2023 Annual meeting and look forward to discussing my completed research in person.



The wonderful Newcastle University setting for BPS 2023



The conference dinner held at the BALTIC Centre for Contemporary Art. (Photo © Zoe Morrall).

British Phycological Society Meeting: Newcastle

Submitted by: Mr Jincheng Wu

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I attended the 71st Annual Meeting of the British Phycological Society, from 24-27 Jan 2023 in person. It was held at Armstrong building in the School of Natural and Environmental Sciences, Newcastle University, UK.

The British Phycological Society organises this Annual Meeting each year at different locations throughout Britain and Ireland. It provided an opportunity for all the algae researchers in the UK to share their research highlights. The organiser also created a comfortable networking environment for early career researchers and senior members. I gave an oral presentation, under the title of Investigation of membrane fouling in microfiltration harvesting of microalgae: *Nannochloropsis oculata*. Personally, I felt my presentation needed improvement. Indeed, I received

constructive comments from one of the audience members: "Your gesture and eye interactions are active, and the slides, content and text font were all excellent, even for those with little experience. You just need to practice the rhythm of the presentation to raise the audience's interest and help them focus on your highlight."

I also got two questions at the Q&A session, the first question is about cell deformation and bursts under high pressure. I said under 2 bar pressure, they remain unbroken under 6 bar from my lab observation, also mention research on compressing algae filtercake to over 100 bar. The second question is about the suspension rheology and the cell wall strength. I addressed the cell reproduction process of *Nannochloropsis oculata* and how the EPS

changes the viscosity of the seawater, the cell wall strength was related to it being made of polysaccharide.

Although some talks were outside of my knowledge comfort zone, I was still fully engaged and enjoyed all the interesting research about microalgae and macroalgae. Two of them are quite impressive, and I've even read their research publications before. The first is the *Ulva* biomass processing via steam explosion in a pressurised cooker (35 bar, high temp), and bio-crude was obtained directly (majorly L-Rhamnose). The second is the phototaxis behaviours of dinoflagellate algae *Chlamydomonas reinhardtii* presented by Cambridge lab. I also met a few friends, Dr Annesia Lamb from Bournemouth University, and Mr Shotaro Hirata from the University of Leeds. We shared our progress and fun things in research and found some in common experiences.

I also had a very pleasant conversation with some journal editors and heard about some interesting projects. This meeting connected me with this large algae community in the UK. I appreciate the BPS student bursary (2022_BPS_0174), which funded my trip and allowed me to attend this annual meeting.



Phycology in a Changing World

Plenary: Nova Mieszkowska - *Time series and ecological genomics: a multi-disciplinary toolbox for the Anthropocene*

Climate change and ocean acidification are occurring throughout the global oceans, and the biogeographic ranges of macroalgae are shifting to higher latitudes as temperatures and oceanic pH levels change. Long-term time-series are invaluable in tracking these shifts and providing contextual data with which to analyse the rates of change. The attribution of changes to specific drivers, however, requires an understanding of the biological mechanisms underpinning the observed responses. Emergent technology is facilitating a novel omics-to-ecosystem approach to determine which factors are causing the observed shifts in population abundances and range limits of marine algae, and how species are responding at genetic and physiological levels. Using rocky intertidal species as a test system, the impacts of multiple stressors are being tracked and quantified around the coastlines of the UK and northern Europe, and the development of ecological genomics is furthering our knowledge of how and why these species-specific responses are occurring.

Mollie Allerton: *Understanding changes in estuarine and coastal phytoplankton communities*

Changes in nutrients, climate, and other water quality parameters have implications for estuarine and coastal phytoplankton communities. Nutrient imbalances have occurred due to differences in management practices. Phosphorous has been more successfully reduced, primarily through sewage treatment and regulatory action on cleaning products, whereas nitrogen concentrations have remained elevated, particularly those from diffuse agricultural sources. Changes in other nutrients, suspended particulate matter, and climate, are also likely to contribute and exacerbate. Long-term time series in the Water Framework Directive (WFD) and Oslo Paris agreement (OSPAR) assessment areas in northwest England have been analysed to identify any shifts in community composition which have occurred in phytoplankton. Using the plankton index tool, changes in the relative abundance of lifeform pairs are examined, as well as changes which may be occurring at a finer taxonomic scale. The aim is to understand the drivers behind these changes and how this understanding can be translated into ensuring the most effective monitoring and management strategies.

Sophie Corrigan: *Home sweet home: Habitat provisioning by a UK sugar kelp farm*

Seaweed farming in Europe is expanding rapidly to meet growing market demand. Farms may also provide environmental benefits, including habitat provision, coastal protection, and bioremediation. Habitat provisioning by seaweed farms remains largely unquantified, and studies examining farm biodiversity have focused primarily on the detrimental effects of epibionts, rather than their roles in ecological functioning and ecosystem service provision. We monitored the development and diversity of epibiont assemblages on cultivated sugar kelp (*Saccharina latissima*) at a farm in the Southwest of the United Kingdom, and compared the effects of different harvesting techniques on epibiont assemblage structure. Epibiont abundance and diversity increased throughout and beyond the kelp growing season, reaching an average of >6,000 epibionts from nine phyla per kelp plant by late summer. Assemblages were dominated by amphipods, bivalves and bryozoans, which, despite providing important ecological roles, reduce crop quality. Partial harvesting techniques maintained, or increased, epibiont assemblages beyond the farming season, however these kelp plants were significantly fouled and would not be commercially viable in most markets. This study improves understanding of how different farming techniques affect epibiont colonisation and assemblage development, which can inform future development of sustainable, ecosystem-based approaches to aquaculture.

Tom Fairchild: *Upscaling biodiversity-ecosystem function relationships using canopy-forming seaweeds as a model system*

Understanding biodiversity-ecosystem functioning (BEF) relationships is a perennial problem in ecology, with a current focus on how BEF relationships may vary depending on the spatial scale on which they are considered. Evidence from small-scale experimental plots suggests that biodiversity can increase ecosystem functioning through higher functional complementarity, but biodiversity benefits may strongly depend on the degree of heterogeneity within habitat patches. Yet when considering greater spatial scales, heterogeneity is likely to increase, incorporating a greater number of habitat features and environmental gradients. As such, a greater diversity of species -with different traits and environmental optima - is likely to be necessary to maximise functioning at larger scales with more environmental contexts. Recent theoretical and simulation studies support this assumption.

tion, but real-world tests of these scaling relationships are lacking. Here, using intertidal forests as a model system, we examine how species diversity functioning relationships change from patch to national scales, across a wide variety of local, landscape and latitudinal contexts. Using spatially-explicit field surveys spanning from the Cornwall to the Hebrides, and incorporating emersion, exposure, temperature and light gradients, we present our preliminary findings for these scaling relationships, and highlight what's next for BEF-scaling research.

Rodney Forster: *Distribution of phytoplankton functional types in a changing North Sea*

The North Sea is a site of great ecological and economic wealth. Favourable underwater light conditions together with suitable nutrient conditions allow the growth of phytoplankton, and diatoms in particular. As microscope-based taxonomy can underestimate the abundance of small-celled nano- and pico-phytoplankton, pigment-based methods offer a means of establishing the composition of phytoplankton functional types and also provide high-quality in situ data for validation of satellite remote-sensing images. Sample collection for high-pressure liquid chromatography (HPLC pigment fingerprinting) was initiated for surface waters of the entire North Sea on the summer cruise of the RV Cefas Endeavour in August 2010 and repeated in subsequent years. Seawater filtered on GFF filters was stored at -80°C and analysed by an accredited laboratory (DHI Water Quality Institute; Hørsholm, Denmark) for chlorophyll a (Chl a) quantification and full accessory pigment analysis. This talk describes diagnostic pigment analysis of the quality controlled multi-year data set to relate the composition of specific accessory pigments to the relative contribution of different size classes to the total phytoplankton biomass.

Hannah Kemp: *Experimental effects of light and temperature on the growth and formation of blanket weed blooms at the mesocosm scale*

Shallow freshwater ecosystems are experiencing increasingly frequent blooms of macroalgal blanket weed, causing negative impacts on waterbody ecology and aesthetics. Although elevated nutrient concentrations in freshwaters provide a pre-requisite for excessive algal growth, much less is understood about other abiotic factors controlling bloom growth rate and extents. To address this knowledge gap, we carried out a series of mesocosm experiments to investigate the effects of light intensity, photoperiod and water temperature on the growth and surface bloom formation of blanket weed. These novel experiments combined underwater and surface photography to quantify change in algal area over time. We found there is a minimum combined photoperiod and light intensity requirement, for bloom formation and substantial algal growth. Surface blooms did not occur when the photoperiod was too short, suggesting day length is a limit-

ing factor. We also found that temperatures between 16-22°C were the thermal optimum for algae to form surface blooms, whilst the highest growth rate of algae on the sediment occurred at 14°C. With the increasing impact of climate change on freshwater ecosystems, these data will help predict the occurrence of surface blooms and assess which waterbodies could be under threat of blanket weed blooms in the future.

Zoe Morrall: *Does mechanically removing algal mats offer a suitable remediation method to improve coastal water quality and reduce nutrient pollution?*

Increases in nutrients from agricultural runoff, sewage discharge and industry lead to widespread eutrophication, often resulting in extensive algal mat coverage in the coastal zone. These mats decrease light availability, increase siltation, accumulate organic matter and increase anoxic conditions impacting key coastal habitats (e.g. seagrass and saltmarsh) and species (wading birds, fish and shellfish). Although reducing the nutrient inputs is paramount, many studies have suggested direct mat removal as a cost effective and immediate solution to begin to achieve nutrient reduction. However, no studies have assessed the efficacy and impact of removing algal mats from intertidal mudflats. In summer of 2022 at four sites in the Channel region (2 UK and 2 French), we assessed the success and ecological effects of removing approximately 400 m² of algal mat using a floating boat platform. Data on removal efficiency will be gathered at the time of removal. Subsequent repeated sampling of the sites over 6 months will monitor both short and longer-term effects including: algal mat recovery, sediment changes, benthic community and wading bird behaviour (e.g. feeding). Removal amounts will then be scaled at the regional level to calculate the potential bioremediation of mechanical removal for nitrogen and phosphorous and also compared to other approaches (e.g. habitat restoration). This novel scientific assessment at relevant temporal and spatial scales will enable European policymakers to make evidence-based decisions to achieve nutrient neutrality and Good Environmental Status, as well as assess the impact of physical removal as a way to combat smothering of key habitats such as saltmarsh and seagrass.

Helen Powley: *Coccolithophores as predators: investigating the impact of modelling coccolithophores as mixoplankton on the ecosystem functioning of shelf seas*

Coccolithophores, an iconic signature phytoplankton, have been recognised as an important functional group in microbial communities for decades and are one of the most abundant calcifying primary producers in the ocean. Recent studies have shown that coccolithophores are capable of bacterivory. This ability of coccolithophores to engage in phototrophy plus phagotrophy for nutritional needs has led to a change in their ecological status from phytoplankton to mixoplankton. Over the last decade,

mixoplankton, protists that obtain nutrition through both phototrophy and phagotrophy synergistically, have been shown to be ubiquitous in the global ocean, leading to the recognition of the mixoplankton paradigm in marine ecology. The mixoplankton paradigm has been implemented in a few recent modelling studies showing their importance in oceanic biogeochemical cycling. However, none of these models have represented coccolithophores as mixoplankton. For the first time, we investigate the importance of coccolithophores as mixoplankton within a marine ecosystem model. The Perfect Beast model was coupled to a one-dimensional water column model and run at a site of coccolithophore bloom initiation on the NW European shelf. We will present preliminary findings focusing on the impact of modelling coccolithophores as mixoplankton versus as phytoplankton on ecosystem dynamics and biogeochemical cycling.

Jordi Sola: *Local effects of heterogeneity on the structure and functioning of rocky shores*

Rocky shores are heterogeneous systems characterized by high topographic variation that is strongly linked to species interactions, diversity of communities and ecosystem functioning. While ecological effects of heterogeneity have been explored for specific cases, we lack a more generalised understanding due to the multiplicity of terms and concepts lacking a central organising framework, and a shortage of empirical studies spanning environmental contexts and time points. To address these issues, I used a combination of literature synthesis and experimental studies focused on rocky shores. I reviewed literature and classified heterogeneity variables into six facets and performed a meta-analysis to quantify their effects on multiple diversity and functioning metrics. I also experimentally tested effects of heterogeneity using rough and smooth tiles deployed along the intertidal emersion gradient and monitored for three years. Results indicate a predominant role of heterogeneity in the structuring and functioning of rocky shore communities, which can change depending on environmental conditions and have further implications that those captured in single sampling events.

Citizen Science & Sci Art

Plenary - Phoebe Lewis: *An Alternate Catch: Seaweed Pigments*

Phoebe Lewis is an industrial designer focusing on developing products that help restore marine ecosystems and coastal communities. Her practice is firmly rooted in the belief that restoration and community collaboration are vital to the progression of sustainable, harmonious design. Since graduating, she continues to expand on her research into the UK's macro algae industry from a scientific perspective during her MPhil in Marine Science. She aims

to develop a more comprehensive pigment range from seaweed for commercial applications such as textile dyes and paint. Current pigment production is a well-known system of water contamination and pollution via the over-consumption of finite resources and fossil fuels. Seaweed has the potential to offer a multi-faceted solution to this by blending scientific research with design application. Phoebe's body of research focuses on a waterless extraction method for seaweed pigments as well as valorising the waste streams from this process to produce further pigments.

Susi Arnott: *Slimewatch 2 - this time it's Deptford*

An interactive science-art exhibition, Slimewatch1, showed in London galleries and BPSs 2020 conference. Photography & time-lapse, microscopy and data-visualisation documented hidden tidal biofilms of St. Saviour's Dock, central London.

Martyn Kelly: *15 years of the Hilda Canter Lund Prize*

The Hilda Canter-Lund Prize has been a regular feature of the British Phycological Society's year since 2008. In this talk, winning and shortlisted images will be evaluated from the perspective of art criticism rather than science. Whilst there are exceptions, successful microalgal photography often tends towards abstraction whilst macroalgal photography often draws on tropes of surrealism. Microalgal photography, in particular, often straddles the boundary between representation and abstraction, with a viewer's reaction to an image heavily dependent upon their prior experience of algae. This emphasises the importance of the legend as a means of communicating the content of an image to non-technical audiences. Whilst there is more to a winning image than technical quality alone, a few simple edits can often enhance an image to increase the chance of being shortlisted. However, the key attribute of a winning image, whether taken on a smartphone or a highly sophisticated photomicroscope, is the decisive moment: being ready for the moment when the opportunity for a great image presents itself.

Heather Sugden: *A best practice framework for co-created citizen science*

In recent decades, citizen science, the active involvement of non-scientists in scientific research, has emerged as a powerful and cost-effective means of generating extensive ecological data sets across a multitude of ecosystems. Involvement in such projects can increase environmental stewardship as participants develop a greater appreciation of natural environments and can enhance participant wellbeing through mental stimulation, social interaction, and improved fitness. In the marine realm, temperate reefs provide a tractable and accessible sys-

tem for citizens to participate in scientific research. Citizen science is generally categorized into three practices: contributory, collaborative or co-created. Contributory and collaborative projects are described as those that are designed by scientists. Co-creation is the most participatory of the three models, where citizens and scientists work together to define the problem, outline the research needed, and follow the scientific process together. Here, we present a framework for the co-creation of citizen science projects based on working with diverse communities in temperate reef systems. Through this active hands-on approach, we raise awareness towards empowering communities and fostering working partnerships between citizens and scientists. We draw on inclusivity and adaptation to ensure that all stakeholders benefit from the process, and we discuss the challenges inherent in undertaking such an approach.

Biotechnology

Plenary - Jessica Adams: *Steam explosion of green macroalgae *Ulva* spp. and the potential of this as a novel processing technology*

Steam explosion is a biomass processing technology where the material is steam-heated to pressures of up to 15 bar, before being rapidly depressurised, causing the biomass to physically separate. Most typically used for lignocellulosic biomass, it has recently been trialled on problem bloom macroalgae *Ulva* spp. (predominantly *U. prolifera*). The material was collected in July 2022 from Milford Haven where it is a perennial problem within the waterways. *Ulva* contains relatively high concentrations of the valuable and unusual sugar rhamnose which can be released in monomeric form following extractions using heat and pressure via an autoclave. This talk will present data generated following a range of variable-conditioned autoclave extractions including using standard and alternative pre-treatments of sulphuric and phosphoric acid respectively. It will then present scaled-up data using a pilot-scale steam explosion rig, capable of operating at significantly higher pressures and more exact retention times. Quantification of rhamnose and other sugars in the solid and liquid fractions will provide data on efficiency of conversion under each condition. Steam explosion of green macroalgae is a highly novel combination with only one paper identified to date peripherally conducting similar experiments, making this highly novel work.

Gary Caldwell: *Living biocomposites: immobilising microalgae and cyanobacteria for industrial applications*

The importance of microalgae and cyanobacteria for biotechnological and industrial applications continues to grow; however, they are prevented from achieving their full value potential by the need to deploy them either

in suspension (e.g., raceways and photobioreactors) or in well irrigated biofilm systems. A more recent technology involves the deliberate immobilisation of cells into biocomposites, with early applications in carbon capture and wastewater bioremediation. Biocomposites comprise three core features; a structural substrate, a biocompatible binder, and the living cells. Here, we detail the development of algae and cyanobacteria biocomposites, focusing on systems that are designed to operate without maintenance for a minimum of three months. We present the state-of-the-art, including demonstrating the capacity to design the binder chemistry to improve biocomposite efficiency and robustness. Finally, we will outline the plans for the first pilot-scale biocomposite project (Ofwat, SuprLoofah) to capture and recover phosphate from wastewater from an unstaffed UK rural wastewater treatment plant.

Ethan Clarke: *A GIS study into colocation: Macroalgae aquaculture and Offshore wind*

The UK government has set the ambitious target of installing 50GW of offshore wind energy by 2030, tripling the current installed capacity. This rapid expansion of offshore wind gives way to new opportunities for other industries to utilise offshore marine space through co-location. Co-location is the sharing of space between two separate industries for a mutual benefit; such as infrastructure, personnel, and operations collaboration – ultimately reducing costs for both industries. Macroalgae aquaculture is a good contender for co-location with offshore wind due to it requiring minimal external inputs and less operations management the other forms of aquaculture. Macroalgae can be used for a wide variety of products including, biofuels, fertilisers, pharmaceuticals, cosmetics and food additives. Currently, many nations, including the UK, are not only in an energy crisis but also a food crisis due to lack of fertilisers. Upscaling of the macroalgae aquaculture industry into offshore marine space would enable macroalgae biofuels and fertilisers to become cost competitive with other traditional sources. This project aims to map the most suitable offshore wind farms for macroalgae aquaculture within the UK EEZ through utilising GIS mapping software. 5, UK native, species were chosen, and their suitable environmental conditions analysed. The parameters mapped included; sea-surface temperature, salinity, nitrate concentration, photosynthetically active radiation, current velocity, and wave height.

Karen MacKechnie: *Algal inks, the future sustainable alternative for labelling*

Algal derived inks are receiving increasing attention as sustainable replacements for petroleum-based or inorganic inks. Certain food and drinks companies strive to increase their sustainability credentials through using naturally occurring, biodegradable products in their packaging and labelling. Therefore, there is an urgent demand to

advance the technology readiness level and make available pigments from algal sources. A working consortium formed of SAMS, CCAP, and Living Ink Technologies (the leading US company in algal inks) have been engaged in projects, supported by Algae-UK and the European Institute of Innovation & Technology (EIT), to expand the range of algal colours the company can use. Several algal and cyanobacterial strains were scaled-up and harvested using the CCAP-ARIES facility. The stability of the pigments from these strains were tested under various pH and temperature conditions, representative of those experienced during the printing process. The raw biomass material underwent in-house testing at the Living Ink Technologies and processed for printing of newly designed labelling products. Investigating and applying methods for growing and harvesting algal biomass and investigating impacts of process production for the suitability of inks are necessary steps in the endeavour to produce carbon negative inks and increase the sustainability of the printing industry.

Annesia Lamb: *Green Seaweed Mat Dynamics in The Channel Region, Genetic Identification, Abundance, and Seasonal Nitrogen Storage*

The Rapid Reduction of Nutrients in Transitional Waters, RaNTrans project aims to remove nutrients using polychaetes, oysters, and seaweed. To understand maximum nutrient removal in seaweeds and the impacts of high biomass accumulations on estuarine organisms (ie. macrofauna), dynamics of mat accumulations in estuaries across The Channel were studied. We collected monthly biomass measurements, seasonal mat species composition and percent carbon and nitrogen at high, medium and low mat concentrations at four sites, two in the UK and two in France. Mat biomass was highest in the summer months across all sites with various laminar and tubular species (ie. *Chaetomorpha* and *Ulva* spp). We used next generation sequencing (NGS) and cleaved amplified polymorphic sequences (CAPS) assay with bulk sample collection to identify seaweed species. Percent nitrogen showed that maximum nitrogen removal using seaweed would occur during the summer months with a percent N as high as 4.5%. The RaNTrans project is investigating cost effective ways of removing nutrients from estuaries and exploiting mat biomass for human benefit. In this way, we aim to create better management options for estuaries subject to eutrophication.

Abi Perrin: *CyanoTag: high-throughput protein tagging in photosynthetic bacteria*

Photosynthetic bacteria are fundamentally important to aquatic ecosystems and global carbon cycling and have exciting potential for use in sustainable bioindustries. However, much of their basic biology is not yet understood and their genomes still contain large numbers of uncharacterised protein-coding genes. To accelerate our

understanding of these essential microorganisms we have developed a high-throughput pipeline for the scarless integration of tags that facilitate protein localisation and interactome profiling in the model cyanobacterium *Synechococcus elongatus* PCC7942. We have used this CyanoTag platform to fluorescently label over 400 *S. elongatus* proteins more than 15% of the proteome. Localisation of these proteins via super-resolution imaging has provided novel biological insights into a diverse range of processes including the regulation of photosynthesis and cell division. We are now expanding the CyanoTag library to the whole *S. elongatus* proteome, building an interactome, and collaborating to increase the benefit of the CyanoTag resource for the wider research community.

Jincheng Wu: *Investigation of membrane fouling in microfiltration harvesting of microalgae: Nannochloropsis oculata*

A dilemma in microfiltration filtration algal harvesting remains the membrane contamination by the foulants including suspended single cells and their Extracellular Polymeric Substances (EPS). In this study, dead-end microfiltration is used to harvest oil-rich marine microalgae *Nannochloropsis oculata*. Batch filtration experiments using 1.5 μ m pore size glass-fibre membranes were carried on under a transmembrane pressure of 5-200 kPa. We aim to clarify fouling mechanisms: 1) pore plugging, 2) entrance blocking, and 3) filtercake, and to evaluate the role of EPS and microalgae cells in microfiltration by additional rheology tests. Experimental data were interpreted using a dead-end filtration model to monitor the permeability variation of the algal filtercake. Our results show that fresh algal suspension show enhanced filterability compared to aged suspension, as less amount of EPS and algal-cell debris slow down the fouling. In addition, the decrease of the filtercake permeability with increasing TMP is evaluated in a power-law expression, giving a compressibility index of 0.93 ± 0.01 . And the invasion of microalgal cells into the membrane under a microscope suggests the deformability of the cells upon entering membrane pores. Finally, the synergy of Fe^{3+} coagulation and filtration displayed higher permeability and mitigated pore plugging and entrance blocking compared with uncoagulated suspensions.

General Phycology

Harry Catherall: *Changes in Laminaria hyperborea holdfast and stipe-associated macroinvertebrate assemblages along gradients of historic mining pollution*

Kelp forests form some of the most productive and critically important marine habitats on Earth. Many studies have described the macroinvertebrate assemblages associated with kelp holdfasts and stipes, however, the

impacts of environmental pollutants on these assemblages have been relatively understudied. Stretches of the northeast coastline of England have been heavily impacted by historic coal mining operations, that in some locations dumped over 40 million tonnes of mining spoil onto the coastline. This led to the loss of key intertidal and shallow subtidal ecosystems, including kelp forests. In the 1990s millions of pounds was spent on cleaning up this spoil waste and kelp forests have since recovered. The impacts of this historic mining persist, however, with elevated levels of metal pollutants detected in kelp tissues. In order to investigate the impacts of this historic mine waste on the holdfast and stipe associated macroinvertebrate fauna 6 sites were sampled along a gradient of mining impact. Heavy metal (Al, Cu, Fe, Mg, Mn, Pb, and Zn) concentration of holdfast tissue was determined using inductively coupled plasma optical emission spectrometry. Holdfast and stipes were also collected from these sites and macroinvertebrate diversity, richness and assemblage structure were determined. Our results indicate a reduction in richness and diversity and an altered macroinvertebrate assemblage with increasing levels of pollutants, with shifts observed in key functional groups across this gradient. Our results suggest that macroinvertebrate assemblages can act as indicator species for areas recovering from industrialisation.

Ottavio Croze: *Microalgal motility through day/night cycles*

We have characterised the motility of the swimming microalga *Chlamydomonas reinhardtii* as a function of day/night cycles, to which the microalgal growth is entrained. Intriguingly, we find that the microalgae swim almost twice as fast during the night than during the day. I will connect this result with the bioenergetics of flagellar propulsion, discussing consequences for the distributions of cells in lab-based and environmental water columns.

Eric Harris-Scott: *Assessing the impact of deployment location on sugar kelp (*Saccharina latissima*) mortality, growth, and condition and ecosystem provision.*

Kelps are one of the fastest growing organisms in the world, thriving on nutrients suspended in the waters around them; when cultivated at scale, can remove large quantities of nitrogen (N) and phosphorous (P) from coastal ecosystems. Marine nutrient pollution is an increasing issue around the world with climate change and coastal urbanisation making it harder to curb growing eutrophication. The majority of wastewater produced on land by anthropogenic activities is discharged, with varying levels of treatment, into the coastal environment from point/non-point sources. Through the deployment of kelp longlines in three locations in the NE Atlantic, with varying environmental conditions and nutrient inputs, this research aims to assess the ability of sugar kelp to be utilised as a coastal management tool in eutrophic areas. Monitor-

ing growth rate and measuring the amounts of N and P in kelp biomass across sites to determine the environmental variables including water temperature, turbidity, salinity and dissolved oxygen that are the key drivers of change in the assimilation rates of N and P. Stable isotope analysis of in the kelp biomass will provide information on the provenance of assimilated N and inform policy decisions to identify and combat directly point and non-point N sources.

Hannah Earp: *Life on the forest floor: spatio-temporal variation in *Laminaria hyperborea* understory assemblages across the UK*

Kelp, large brown macroalgae of the order Laminariales, are ecosystem engineers that form forests along one quarter to one third of the world's temperate and sub-polar rocky coastlines. The three-dimensional structure of the forest modifies local environmental conditions, which in some regions, allows diverse understory algal and macrofaunal assemblages to develop. These understory assemblages, however, represent somewhat overlooked components of kelp forest ecosystems, with fundamental information on their structure and functioning often lacking. Here, we used an underwater suction sampler to characterize understory macrofloral and macrofaunal assemblages within *Laminaria hyperborea* forests across four regions of the United Kingdom. Specifically, we investigated spatial and seasonal variation in the structure and diversity of assemblages along a 9 degree latitudinal gradient which represented a 2.5°C gradient in sea surface temperature. Collectively, the samples comprised of 2.4 kgs of understory algae and 65,419 macrofaunal individuals from 179 taxa. We found significant spatial and seasonal variation in the abundance, richness, diversity, and evenness of understory assemblages, likely because of complex interactions between sea surface temperature, wave exposure and habitat structure. Given that kelp forests are becoming increasingly threatened by multiple stressors, it is important that we generate baseline information on the structure and functioning of understory assemblages which, when coupled with information on the kelp itself, can serve as a benchmark to successfully monitor, manage, restore, and ultimately conserve entire kelp forest ecosystems and their associated ecosystem services.

Peter G. Kroth: *Aureochromes peculiar photoreceptors in diatoms*

Aureochromes (AUREOs) are a relatively novel type of blue-light photoreceptors in algae (discovered in 2007), and they so far have only been found in Stramenopiles. They have a very peculiar structure: In addition to a blue-light sensing flavin-binding LOV-domain, they possess a DNA-binding bZIP domain, that is typically found in transcription factors. Therefore, aureochromes can be considered as light-driven transcription factors, allowing

very fast responses. The pennate diatom *Phaeodactylum tricornutum* possesses four different aureochromes (PtAUREO1a,1b,1c,2), which are expressed differently throughout the day. We have generated PtAureo knockout cell lines of the diatom *P. tricornutum*. PtAureo1a knockout mutants showed a distinctive phenotype of a low capacity for Non Photochemical Quenching (NPQ), a prominent photoprotection mechanism in diatoms. The role of PtAUREO1a has been confirmed by genetic complementation studies in *P. tricornutum*. In transcriptomics experiments, we found that the knockout of PtAureo1a has a drastic impact on global gene expression of the algae, indicating that PtAUREO1a might function as a master switch for blue light induced responses. Furthermore, a knockout of PtAureo1a has an impact on the diel expression of other regulatory factors. Studies on the potential binding sites of Aureochromes via yeast-1-hybrid analyses indicate that PtAureo1a can regulate its own expression.

Christine A. Maggs: *Life history of red alga Nemastoma dichotomum revealed by NGS*

During sampling of crustose red algae in a fully marine inlet off Kilkieran Bay, Co. Galway, Ireland, in December 1981, a crust was collected in association with small erect axes identified tentatively as *Nemastoma* sp. It was bisporangial and bore large gland cells. If this crust were shown to be part of the life history of *Nemastoma* sp, it would be a new record for Britain and Ireland, as *Nemastoma* had not been recognized in the Irish or British seaweed flora. However, bispores released in culture from the bisporangia gave rise directly (i.e. apomictically) to bisporangial crusts which themselves became fertile as a short-day response. The culture was maintained for three years without forming erect thalli, and then dried and kept as a voucher for the three decades. New developments in molecular methodology (next generation sequencing) allowed us to obtain nearly full plastid and mitochondrial genomes from the original cultures. They are very closely related to Genbank sequences for *Nemastoma dichotomum* from Spain (Islas Columbretes, Western Mediterranean). After near four decades, we can now reveal the morphology of the previously unknown tetrasporophyte of *N. dichotomum* and confirm the presence of this species in Ireland for the first time.

Hannah Thomas: *Understanding alterations in structure and composition of the seaweed-derived gelling agent, carrageenan, following in vitro digestion*

Carrageenan is a marine hydrocolloid extracted from red seaweeds (Rhodophyta) which acts as a functional ingredient in foods such as dairy products and processed meats. Structurally, carrageenan is a polysaccharide composed of alternating sulphated galactose units. Carrageenan has been said to have resistance to gastric and intestinal enzymatic digestion, potentially providing prebiotic characteristics. Understanding the digestive

fate of carrageenan will aid the understanding of how it is utilised by the human gut microbiota and how this impacts on health. Laboratory grade and commercially available carrageenan were digested in vitro, using published methods. Structural and biochemical analysis techniques, Fourier-transform infrared spectroscopy (FTIR), Nuclear Magnetic Resonance (NMR) and High-performance liquid chromatography (HPLC) subsequently conducted on raw and digested carrageenans. NMR spectra demonstrated similarities in the peak distribution between digested and raw carrageenan, however broad peaks suggest enzymes from the digestive process are being carried over into digested end product, partially obscuring the data interpretation. Peaks used to characterize carrageenans were apparent in all FTIR spectra and varied dependent on subtype, as expected. However, digested carrageenan had additional peaks in regions (1700-1300cm⁻¹, 3000-2800cm⁻¹) distinct from raw carrageenan further demonstrating that aspects of the carrageenans structures are conserved during digestion.

Jessica Walker: *Mapping trace elements in coccolithophores using synchrotron light*

Biominerals are challenging to investigate, commonly demonstrating nano-crystalline structures, and organic-inorganic interfaces. They also regularly display heterogeneity in their composition and structure over a range of length scales. As such, hard x-ray nanoprobe beamlines (such as Beamline I14 at Diamond Light Source) offering small probe sizes, correlative compositional information and crystallographic information with mapping functionality are ideal for investigating these complex materials. A key example of biomineralization is coccolithophores, a marine unicellular algae that produces complex arrays of calcite single crystals called coccoliths. Different species of coccolithophore can have variable trace element concentrations, which are usually examined on a bulk scale. Here, using X-ray fluorescence (XRF) and X-ray near-edge absorption spectroscopy (XANES), we are able to map the Sr content within a single coccolith. These techniques have allowed us to show that Sr content can vary both between and within a species of coccolithophore. This can help us understand how the mechanism of formation may vary between coccolithophore species.

Emma A Ward: *Seagrass distribution and spatial variation in quality -seascape context and influences on carbon storage?*

Producing accurate estimates of habitat extent and quality is a prerequisite to determining their ecosystem services (ES) provision, but often variation in quality exists within a habitat, likely influencing ES provision. Seagrass meadows have been cited as important habitats for ES including carbon sequestration, nutrient remediation and coastal protection (sediment stabilisation). To provide accurate data on seagrass ES and functionality, mapping

needs to distinguish both the area and quality of habitat. This study maps intertidal seagrass (species composition and density) and algal mat spatial distribution, as the proliferation of algal mat can reduce light penetration in the water column reducing habitat suitability for seagrass. Sediment cores were collected across several habitat quality classifications from the spatial habitat quality maps, to focus on sedimentary carbon and nitrogen retention within these habitats. The spatial mapping highlights several important factors: i) demonstrable edge effects; ii) high spatial variation in seagrass density are prevalent characteristics, which act as indicators of habitat quality; iii) green macroalgal mat negatively influences seagrass distribution. Therefore, variation within the seagrass seascape (species composition and density), alongside adjacent habitat types (algal mat) within the wider seascape should be considered when assessing ecosystem services provision.

Chris Yesson: *A national Red List for British seaweeds*

The Red List is an internationally recognised system for evaluating the conservation status of plants and animals. Its objective is to create a standardised metric applicable to all life forms. The uptake for seaweeds has been extremely limited, with only 75 species globally evaluated to date. Here we report on recent efforts to create a national Red List for British seaweeds. Observation records from national and regional sources were used to apply IUCN criteria based on a data driven approach. These provisional findings were discussed at a workshop after which categories to which species had been assigned were revised by peer review to create a final assessment. This resulted in 7% of species placed in threatened categories, with a further 9% as near threatened, but approximately 55% of the 617 species evaluated were classed as data deficient. The implications of these findings will be discussed as well as the applicability of IUCN criteria to seaweeds. We will provide a series of recommendations for future evaluations and also issue a call to the community to help record some priority species for future Red List assessments.

Public Lecture

Prof Juliet Brodie: *The Big Seaweed Search: Citizen power and scientific research*

The Big Seaweed Search is a citizen science project where the public are invited to record the presence and abundance of fourteen conspicuous seaweeds. The science investigates the impact of sea temperature rise and ocean acidification, and the spread of non-native species. In this talk, an overview of the project will be presented and how the results from the first four years have contributed to scientific research. Developing the Big Seaweed Search will be discussed with an overview of how the concept has been developed in The Falklands Islands, South Georgia and Mexico.

Posters

Ryan Alexander: *First detection of the cyclic imines pinnatoxin G, 13-desmethyl spirolide C and 20-methyl spirolide G in UK shellfish.*

Harmful algal biotoxins in the marine environment are a constant threat to food safety through their bioaccumulation in bivalve shellfish. Whilst official control monitoring provides ongoing risk management for seafood toxicity outbreaks, no regulatory monitoring system is currently operated in Europe including the UK for emerging non-regulated toxins. To assess the potential presence of these non-regulated toxins, a systematic screen of bivalve shellfish was conducted throughout the UK. A rapid dispersive extraction was used with UHPLC-MS/MS analysis to test for 15 cyclic imines and 7 brevetoxins in 2671 shellfish samples taken from routine testing sites around England, Wales and Scotland in 2018. Out of the 22 toxins incorporated into the method, just three toxins were detected; the cyclic imines Pinnatoxin G, 13-desmethyl spirolide C and 20-methyl spirolide G. The maximum concentrations observed were Pinnatoxin G at 85.4 µg/Kg, 13-desmethyl spirolide C at 13.4 µg/Kg and 20-methyl spirolide G at 51.4 µg/Kg. For Pinnatoxin G the concentration observed was over the recommended guidance threshold. This is the first detection for all three of these toxins in UK shellfish, elucidating to the presence of Pinnatoxin G producing *Vulcanodinium rugosum* or unknown PnTx G producers in UK waters, a phenomenon that has not been reported before in the UK.

Fraser Brough: *Environmental impacts of seaweed cultivation: an overview of recent and ongoing work at a farm in Porthallow, Cornwall.*

Cultivation of microalgae and macroalgae (i.e. seaweeds) currently contributes about 20% of total global aquaculture biomass and is rising rapidly at 8% per year. Seaweed farming has recently emerged in Europe, following market expansion and diversification of uses in products ranging from human and animal food to biofuels and bioplastics. However, a number of knowledge gaps hinder the growth of the seaweed sector. To develop cultivation techniques and investigate the environmental impacts of seaweed farming, the Benthic Ecosystem & Environment CHange (BEECH) group at the Marine Biological Association (MBA) has been working closely with the Cornish Seaweed Company in partnership with Westcountry Mussels at their cultivation site in Porthallow Bay, Cornwall. Here, we provide an overview of recent research activities conducted at the cultivation site, which is a mixed kelp (*Saccharina latissima*) and blue mussel (*Mytilus edulis*) farm. Our research has focused on the optimisation of seaweed cultivation techniques. Trialled over a growing season at the farm, two methods of kelp seeding were applied offering the potential to reduce associated costs with the laboratory grow-out phase. Additional research has inves-

tigated habitat provisioning of seaweed farming, by examining biodiversity supported by cultivated biomass and farm infrastructure and comparing biodiversity patterns between farmed and wild kelp populations. Finally, ongoing work is quantifying carbon dynamics in and around the kelp farm, to determine whether seaweed cultivation can contribute to local carbon sequestration (i.e. Blue Carbon). While there is clear potential for industry expansion, a robust evidence base is needed to inform decision-making and marine management.

Sophie Corrigan: *Home sweet home: Habitat provisioning by a UK sugar kelp farm*

Seaweed farming in Europe is expanding rapidly to meet growing market demand. Farms may also provide environmental benefits, including habitat provision, coastal protection, and bioremediation. Habitat provisioning by seaweed farms remains largely unquantified, and studies examining farm biodiversity have focused primarily on the detrimental effects of epibionts, rather than their roles in ecological functioning and ecosystem service provision. We monitored the development and diversity of epibiont assemblages on cultivated sugar kelp (*Saccharina latissima*) at a farm in the Southwest of the United Kingdom, and compared the effects of different harvesting techniques on epibiont assemblage structure. Epibiont abundance and diversity increased throughout and beyond the kelp growing season, reaching an average of >6,000 epibionts from nine phyla per kelp plant by late summer. Assemblages were dominated by amphipods, bivalves and bryozoans, which, despite providing important ecological roles, reduce crop quality. Partial harvesting techniques maintained, or increased, epibiont assemblages beyond the farming season, however these kelp plants were significantly fouled and would not be commercially viable in most markets. This study improves understanding of how different farming techniques affect epibiont colonisation and assemblage development, which can inform future development of sustainable, ecosystem-based approaches to aquaculture.

Katie Driver: *Conservation of freshwater biology: Under stress from intensive agriculture during a climate crisis*

The purpose of this study was to determine whether zooplankton diversity, abundance and body length are equally effective indicators for eutrophication, with the intention of finding a potential universal measure for freshwater ecosystem health. It also investigated the interaction and main effects of temperature change and nutrient pollution from intensive agricultural run-off. Freshwater ecosystems are an overlooked ecosystem with 90% of lowland ponds being lost in the UK due to human intervention. The experimental setup applied different passive temperature treatments to a series of mesocosm ponds as a simulation for climate change. High coverage blanket weed was used as a surrogate for nitrogenous fertiliser

additions, and zooplankton was used as a proxy for freshwater ecosystem health. Results showed that none of the zooplankton indicators of freshwater biodiversity showed a significant interaction with surface algal cover. However, the preliminary nature of the study and small sample size results in low power and a high margin of error. It would be useful to repeat this study with a greater sample size, more extreme temperature treatments and periodic direct administrations of Nitrogenous and Phosphorous fertilisers. The field would benefit from further research into primary producers as a direct indicator of freshwater ecosystem health.

Hannah Earp: *Weathering the storm: The response of *Laminaria hyperborea* and associated understory assemblages to storm disturbance*

Kelp are important foundation species in coastal marine ecosystems, where they provide a biogenic habitat for an array of organisms and ameliorate environmental conditions which can facilitate the development of diverse understory assemblages. The structure of kelp forests is influenced by a variety of abiotic factors including physical disturbance from wave action. However, intense physical disturbance from storm-driven hydrodynamic forces can have profound effects on the structure and functioning of kelp forests and their associated communities. Given that storms are anticipated to increase in frequency, intensity, and duration in the future, it is critical to understand their impacts on kelp forest habitats. During the 2021/22 North Atlantic storm season, the UK was subject to several intense storms, of which the first and most severe was Storm Arwen. Due to the unusual direction of the wind (northerly as opposed to prevailing south-westerly), the greatest impacts of Storm Arwen were felt along the NE coast of the UK where wind gusts exceeded 90kph, and inshore significant wave heights of 7.2m and wave periods of 9.3s were recorded. Anecdotal evidence following Storm Arwen suggested that the *Laminaria hyperborea* forests along the NE coast of England experienced significant damage. Here, we investigated the impact of the 2021/22 storm season on the structure of *L. hyperborea* forests in SE Scotland and NE England using data collected prior to and following the storm season. We found that the storms dislodged canopy-forming individuals and altered the structure of understory assemblages, although the scale of the disturbance was variable across sites.

Ruby George: *Ecological stability and underpinning mechanisms on rocky shores and artificial coastal defence structures.*

With the severity and frequency of disturbance events such as storms increasing due to climate change, it is important to understand the capacity of ecological communities to withstand and recover from disturbance, i.e., their ecological stability. I present my PhD research plan to unravel the underpinning mechanisms of ecological

stability on hard substrate habitats such as rocky shores and artificial coastal defence structures. The main hypothesis behind my PhD is that topographic complexity is a key determinant of ecological stability on hard substrate habitats as it increases microhabitat diversity, and further influences species diversity and interactions. In turn, a diversity of microhabitats and species theoretically provide disturbance refugia and a repository of species supporting stability. While artificial defence structures are physically simplified, eco-engineering interventions, such as the installation of Living Seawall panels, can be used to enhance complexity and create habitats on coastal artificial structures, increasing biodiversity and potentially ecological stability. I will describe a variety of observational and experimental approaches that I am planning to address the above-described hypotheses.

Hallam Greene: *Trace metals in coccoliths: Manganese uptake in coccolithophores*

Coccolithophores are responsible for ca. 10% of global annual carbon fixation, (Poulton et al. 2007) but the biomineralization process is still not fully understood. Uptake of trace metal ions such as strontium and manganese into coccoliths may shed light on the formation process. Manganese, a known impurity in mineral calcite, has been used in calcite labelling experiments in other organisms (e.g. Gorzelak et al. 2017). In this work, multiple coccolithophore species have been shown to exhibit different fractionation of manganese when grown in Mn-enriched media. The Sr:Ca ratio in *Scyphosphaera apsteinii* has been found to be greater than in other coccolithophores (Meyer et al. 2020), and this work finds a high Mn fractionation for this species. Cleaning studies have assessed to what extent metals are associated with calcite, as opposed to organic components, and the effect of cleaning on the coccolith structure has been examined. From this work we hope to develop pulse-chase experiments using Mn as a label to better understand coccolith formation. We also hope to better describe the concentration and distribution of metal ion impurities in coccolith calcite using XRF and XANES measurements with the I14 hard x-ray nanoprobe

David Hartnell: *The Toxic Algae: A Confluence of Red Tide and Blue-green*

The worlds revealed by light microscopy have always been popularised as art, and who would contest that the illustrations in Robert Hooke's 1665 *Micrographia* are not masterpieces? Here, images of toxic algal reference strains are presented using fluorescence microscopy after treatment with fluorochromic stains used for flow cytometric analysis. Combined with data outputs from scientific instrumentation, including a state-of-the-art High-Resolution Mass Spectrometer. The sci-artist hopes to emulate some of the great painters from renaissance to modern-times, without reference. As with pure science

there will be mistakes, but not all will be unconscious. Therefore, an online survey will be provided, where the viewer's toxic algal knowledge can be assessed, and the artistic influences explored. Additionally, the contribution to sci-art of this installation can be discussed or whether this early career sci-artist should be lucky if they still have a day job to return to.

Shotaro Hirata: *Discovery of carotenes provides a new insight into the genus definition of Ryuguphyucus kuaweuweu (Ulvaceae)*

Ryuguphyucus kuaweuweu is a deep-water Ulvophycean alga distributed in the Pacific Ocean (i.e., Ogasawara Is. & Mageshima I., Japan, and Hawaiian Is., U.S.A.) and is characterized by its unique carotenoid composition: the presence of siphonaxanthin instead of lutein and the absence of carotenes. However, in our preliminary analysis, β - and γ -carotenes were detected by TLC from a culture strain based on Hawaiian material. To confirm this, we used four unialgal culture strains of *Ulva ohnoi*, *Umbraulva yunseulla* (Japan), and *R. kuaweuweu* (Hawaii Is. and Ogasawara Is.), grown under 20, 23, and 25f, 12:12 LD cycle, and 16×10^7 $\mu\text{mol photons m}^{-2} \text{s}^{-1}$. Carotenes from crude extracts were identified by TLC and HPLC analyses using commercial standards products. The *R. kuaweuweu* Ogasawara strain (KU-MACC; KU-3336) was employed in a previous study. We detected carotenes from all samples regardless of the geographical differences. Although the specific conditions resulting zero-carotene accumulation have not yet found, it is likely that this species has an ability to biosynthesize carotene and that carotene accumulation is impacted by environmental conditions. Therefore, the presence or absence of carotene is not a valid taxonomic character.

Tayla Leathers: *The effect of contemporary and projected marine heatwaves on the ecophysiological performance of kelp species with different thermal affinities*

The frequency, spatial extent, duration and intensity of Marine Heatwaves (MHWs) has increased over the past century and is expected to further. Extreme temperature conditions experienced during MHWs can have profound effects on marine organisms, often leading to widespread community and ecosystem level change. Rapid shifts in species distributions - such as contractions at trailing range edges and expansions leading edges have been attributed to MHW activities. The distribution and ecophysiological performance of habitat forming organisms, such as kelp and seagrasses, are strongly influenced by temperature, making them particularly susceptible to anomalous warming events. This study examined how MHWs with differing properties (i.e. varying intensities of moderate (+4°C) and extreme (+8°C) and durations (14 days) (28 days)), impact kelp species with different thermal affinities (i.e. the cool water *Laminaria digitata* and the warm water *Laminaria ochroleuca*). Following exposure

to simulated MHWs, both cool and warm affinity species were negatively affected by extreme warming treatments (+8°C), with responses exacerbated by long duration MHWs. Even the warm-adapted, climate change winner *L. ochroleuca* was adversely affected by extreme warming, with limited signs of post-MHW recovery. Overall, longer exposure to both moderate and extreme MHWs had significant impacts on the ecophysiological performance and survival of all species. This suggests that, under projected trends of increasing duration and intensity of MHWs, mortality events and range shifts will become more frequent, even for predicted climate change winners, likely driving widespread ecological change.

Adam Lewis: *ScillyHAB: A multi-disciplinary survey of Harmful Marine Phytoplankton and Shellfish Toxins in the Isles of Scilly, utilising Citizen Science*

An initial investigative survey was planned to take place in the Isles of Scilly from March 2020 throughout the Summer and into the Autumn. Unfortunately, due to travel restrictions and social distancing, it seemed that the survey would need to be cancelled altogether. However, thanks to the work of enthusiasts, schools and university students based on the Isles of Scilly a modified survey was able to be conducted. Volunteers collected samples and performed initial phytoplankton screening, via portable light microscopes, as well as fixing water samples and posting them to the Cefas laboratories for comprehensive analysis. Further to this, small numbers of shellfish samples were also collected by volunteers, frozen and sent to Cefas for biotoxin analysis. At Cefas, further microscopy, molecular analysis and chemical analytical testing were carried out. Results showed the presence of a number of Harmful Algal Bloom (HAB) taxa as well as low levels of the associated toxins. This indicates that there is the possibility for HAB related impacts in the waters around the Isles of Scilly. This work was made possible through the efforts of citizen scientists in collaboration with Cefas.

Amy Mace: *Toxic phytoplankton recorded around the English and Welsh coast in 2022*

The Shellfish Biotoxin Monitoring Programme was implemented to protect consumers after 78 people displayed symptoms of paralytic shellfish poisoning in 1968. This includes the analysis of flesh samples for the presence of toxic compounds and water sample analysis to determine the presence of toxin producing phytoplankton species. The presence of any potentially toxic phytoplankton acts as an early warning for any developing problems. Cefas analyse water and shellfish samples on behalf of the Food Standards Agency. At the Lowestoft CEFAS laboratory we identify seven toxic phytoplankton taxa as these can produce toxins that bioaccumulate in shellfish flesh when the shellfish consume them. In high enough dosages, these toxins can cause shellfish poisoning such as diarrhetic shellfish poisoning (DSP), amnesic shellfish

poisoning (ASP) and paralytic shellfish poisoning (PSP) when ingested by humans. At the Weymouth laboratory the shellfish flesh is tested for toxin level. The data shows there is continued presence of toxic phytoplankton species in English and Welsh waters at high enough levels to impact the shellfish harvesting. This poster shows an indication of when and where the highest densities of the target taxa are recorded under this monitoring programme.

Suzanne McGowan: *Getting the message right on water quality and wild swimming*

Wild swimming (swimming outdoors in natural blue spaces) has surged in popularity as the physical and mental health benefits are increasingly recognized. Concurrently, publicity surrounding poor water quality in UK inland and coastal waters is escalating, with swimmers often leading environmental campaigns for water quality improvements. Balancing the potential health benefits versus the environmental risks of wild swimming is essential to help (potential) swimmers make informed decisions. In this interdisciplinary Arts and Humanities Research Council project, we identified gaps in information provision to UK swimmers and found that, in contrast to coastal waters, most inland waters (lakes, ponds, rivers) lacked basic water quality information because only a handful are designated swim sites which must legally be monitored. Swimmers were often reliant on swim groups and personal knowledge to help assess water safety. The Bloomin algae app can help to educate swimmers, but there are no user-friendly methods or kits suitable for rapid detection of the most prevalent water quality risks including cyanobacterial toxins and bacterial coliforms. Therefore, we are developing artwork and messaging on environmental and safety risks that could be used to empower swimmers to make realistic risk assessments for deciding when and where to swim.

Rebecca McKinney: *Stimulating phlorotannin production in seaweed for use as an animal feed supplement*

The SeAFEED project aims to provide a comprehensive overview of phlorotannins as a possible replacement for the recently banned zinc oxide (ZnO) in pig feed. ZnO has been traditionally used in diets of pigs being weaned to alleviate microbial, physiological, and immunological stress from weaning. An inexpensive compound, it was used frequently in amounts above the physiological requirements of the animal which resulted in the development of antimicrobial resistances and environmental contamination. As a result of this, the European Commission banned the zinc oxide as a therapeutic agent and growth promoter within piglets in the EU commercial pig industry as of June 2022. One alternative being explored are phlorotannins, marine polyphenols mainly found in brown macroalgae. Target species for this project are *Fucus vesiculosus*, *Fucus serratus* and *Fucus spiralis*, brown macroalgal species native to the North Atlantic. These species have a high

plasticity, adapting to environmental stimuli resulting in varying phlorotannin concentration, ranging from 2-20% dry weight. The main aim of this project is to determine if stressors can be found to stimulate phlorotannin production and how best to optimise growth to ensure stable concentrations in the target species. This will be accomplished through assessing the natural variability of phlorotannins in relation to season, shore height and exposure for the target species. As well as subjecting the target species to anthropogenic manipulation of environmental stressors such as temperature, nutrient availability and light to induce phlorotannin production.

Olivia Parrish: *Variation in understory assemblage composition across several northern and southern intertidal forests in Great Britain*

Canopy-forming algae (wrack and kelp) modify conditions (e.g., light, humidity) and create habitat for distinct understory communities. While the habitat-forming role of canopy is well-recognised, we know little about how understory communities on rocky shores vary, on large scales. The aim of this study is to advance understanding of how understory species composition varies across shores from southern to northern GB, spanning sites of different wave exposure. In both the southern (near Plymouth) and northern (Isle of Mull) regions, I selected mid-shore zones within moderately wave exposed and wave sheltered sites for sampling. Using replicate quadrats, understory species composition was recorded based on in situ and image-based assessment. I will use analysis of variation (ANOVA) to investigate variation in the cover of functional groups in the understory according to region and wave exposure. I will also analyse the roles of canopy identity and biomass, substrate rugosity, and grazer abundance as additional potential drivers of variation in understory composition. The results of this study will forward our understanding of the causes of variation in canopy understory communities as a key component of biodiversity on rocky shores.

Abi Perrin: *Publications & Public Actions: How can Scientists respond to the Climate and Ecological Emergency?*

Planetary heating and the destruction of ecosystems has precipitated a Climate and Ecological Emergency requiring an urgent response. The collective actions taken (or not taken) now will determine the conditions for life for every individual and every species on Earth. Faced with this reality we can feel powerless, but scientists are in a prime position to drive positive change amidst these deepening crises, and there are many routes we can each take to facilitate and accelerate essential global, systemic and societal transitions.

Riddhi Salotra: *Seaweed polyphenols for potential application in animal feeds*

Seaweeds have been reported as a rich source of different bioactive compounds e.g. phlorotannin, bromoforms, proteins, carbohydrates, lipids, alkaloids, and peptides. In recent years, they have become materials of interest for their supplementation into ruminant diets to help in reducing enteric methane emissions¹ and their potential as an anti-microbial agent in animal feeds². A novel method has been developed for the determination of total phlorotannin content in brown seaweeds using ¹H NMR spectroscopy³. The DMSO-d₆ aprotic and strongly hydrogen bonded solvent was used to determine the sharp resonances of phenolic hydroxyl protons in the range of 8-14 ppm and resultant NMR spectrum was recorded with the integration of the specific phenolic signal (previously suppressed), that allowed the quantitation of phenolics in a more accurate manner. This method has been applied to the phenolic rich extracts (produced using conventional maceration extraction technique) of four brown seaweed species (*Ascophyllum nodosum* (AN), *Fucus serratus* (FS), *Fucus vesiculosus* (FV), and *Fucus spiralis* (FSp). The results of the total phlorotannin content (TPC) were compared with standardised Folin-ciocalteu (FC) reagent method to ensure the correlation between the two quantitative methods. The results from the NMR have shown that the highest TPC was observed for FV, while the lowest for FSp and a similar trend of TPC variation was calculated using FC assay with the highest TPC in FV and lowest in FSp. This showed good correlation between the two quantitative methods and ensures more accuracy for determining total phenolics in extracts. Work is ongoing now to develop more sustainable processing methods for the extraction of seaweed bioactives using greener processes that will retain the bioactivity of the extractions. Supercritical CO₂ is now being trialed to produce phenolic rich extracts. Furtherwork involves optimising the supercritical CO₂ extraction process and screening the extracts for their bioactivity as a potential anti-methanogenic agent.

Alfie Watton: *Association between common limpets (*Patella vulgata*) and macroalgal cover: variation between northern and southern rocky shores in Great Britain*

The common limpet, *Patella vulgata*, interacts strongly with macroalgae on UK rocky shores. While these species can greatly influence macroalgal cover through grazing, they also respond to macroalgal cover, with canopy forming fucoids creating a protective habitat. Studies carried out in Great Britain between northern and southern shores have indicated a difference in feeding habits. Northern populations consume more canopy forming macroalgae, while in southern regions they consume more microalgal species. Additionally, as desiccation stress is expected to decline between southern and northern areas, the importance of canopy macroalgae as protective habitat may also decline. Therefore, relationships between limpets and canopy may vary with latitude. As a Year in Research undergraduate

student, I have been assisting with rocky shore field surveys around Great Britain. Rocky shore communities were sampled across multiple sites and regions, from Plymouth to the Isle of Mull. I will report preliminary exploratory analysis of the relationships between limpet density and the cover and biomass of furoid algae within the mid-shore using data from two northern and two southern GB rocky shores. These results may have implications for our understanding of how biotic factors shape macroalgal communities across large spatial scales.

Johanna C Winder: *The ice-binding proteins of Fragilariopsis cylindrus: a computational exploration of genetic, structural, and evolutionary features*

The genome of the polar diatom *Fragilariopsis cylindrus* encodes over 47 putative ice-binding proteins (IBPs) containing a domain of unknown function 3494 (DUF3494). The biological role of their diversity has only been minimally explored. Here, a computational approach was used to update the catalogue of IBPs from *F. cylindrus*, predict subcellular localisation and structural motif presence, model structures, and compare sequences with other polar algal species. This analysis reveals structural diversity upstream of the DUF3494 domain in many fclIBPs. Several are predicted to be membrane bound, with the definitive presence of one nuclear localisation signal and other suggestions of plastid localisation. Structural modelling with AlphaFold reveals variation in the IBPs. Structural features are sometimes associated with surrounding gene architecture: for example, genes encoding nucleic acid binding proteins flank a triple-domain IBP in the genome. Furthermore, comparing IBP sequences between eukaryotic algae provides evidence for multiple independent origins of IBPs in *F. cylindrus* supporting acquisition of these genes via HGT.



Irene Manton Award Winners

71st Annual Meeting of the British Phycological Society – Manton Prize/ Student bursary report

Submitted by: Hannah Kemp

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It was so great to finally be in person at BPS2023 after two years of seeing everyone's faces online! The algal community is always so welcoming and it was great to meet, learn from and socialise with so many scientists from across the broad spectrum of phycological research.

I am in the final year of my PhD with Envision DTP, based in the School of Geography at the University of Nottingham and working in partnership with the National Trust. My PhD research is all about bloomin' blanket weed! This is the freshwater macroalgae that forms thick green mats on the surface of lakes, ponds and wetlands in the warm summer months. These blooms can have a number of negative impacts on freshwater ecosystems as they shade benthic ha-

bitats and cause anoxia during decomposition. Blooms can also reduce how much people enjoy waterbodies as they impede activities and smell pretty bad! Therefore, it is critical we investigate and learn more about what is driving these blooms in order to manage them in the future.

Over 18 months of my PhD, I carried out regular monitoring of a shallow lake that experiences prolific blanket weed blooms at Clumber Park, a National Trust property in north Nottinghamshire. Bioassay experiments and water chemistry monitoring found that Clumber Lake receives highly nutrient rich water from the River Poulter which means the algal growth is unlikely to be nutrient limited at any point of the year. As is the same for many freshwater bodies



across the country, if we want to control the shear biomass of macroalgae, then we need to control the nutrient inflow. However, it is clear there are other drivers causing the algae to move and form blooms at the surface. So, this is what I investigated next!

Earlier this year I carried out a series of experiments in the Limnotron Facility at the Netherland Institute of Ecology (NIOO- KNAW), funded by AQUQCOSM. The Limnotrons are 9 stainless steel barrels, each containing 1000L of water, and provided the perfect mesocosm set-up to test the effects of daylength, light intensity and water temperature on the growth and formation of surface blooms of blanket weed algae. These novel experiments combined underwater and surface photography to quantify change in algal area over time.

The experiments found that surface blooms of algae did not occur when the photoperiod was too short, suggesting day length is a limiting factor in bloom formation. We also found that temperatures between 16-22°C were the thermal optimum for algae to form surface blooms. With the increasing impact of climate change on freshwater ecosystems, these data could help predict the occurrence of surface blooms and assess which waterbodies could be under threat of blanket weed blooms in the future. I thoroughly enjoyed my time at the NIOO, and even the King of the Netherlands popped in for a visit and saw the algae in action!

It was a pleasure to share my research at BPS2023 and I am so thrilled to have won the Irene Manton presentation award – thank you! I am always amazed by the range of phy-

cological research presented and talked about at BPS conferences and it was particularly great to see so many of the presentations given by fellow students and ERCs. A theme that ran through the conference, including the public lecture given by Juliet Brodie, was the role of citizen science in algal research. Engaging the public is the key to expanding our knowledge and inspiring others to make a difference.

Finally, I would like to say a huge thank you to the Newcastle organising team for putting on a brilliant annual meeting. Hopefully, I shall see many of you again next year!

Thank you to the BPS for both my student bursary award (2022_BPS_0059b) and the Manton prize award (2023_BPS_0209).



The ice-binding proteins of *Fragilariopsis cylindrus*: a computational exploration of genetic, structural, and evolutionary features

Miss Johanna C. Winder

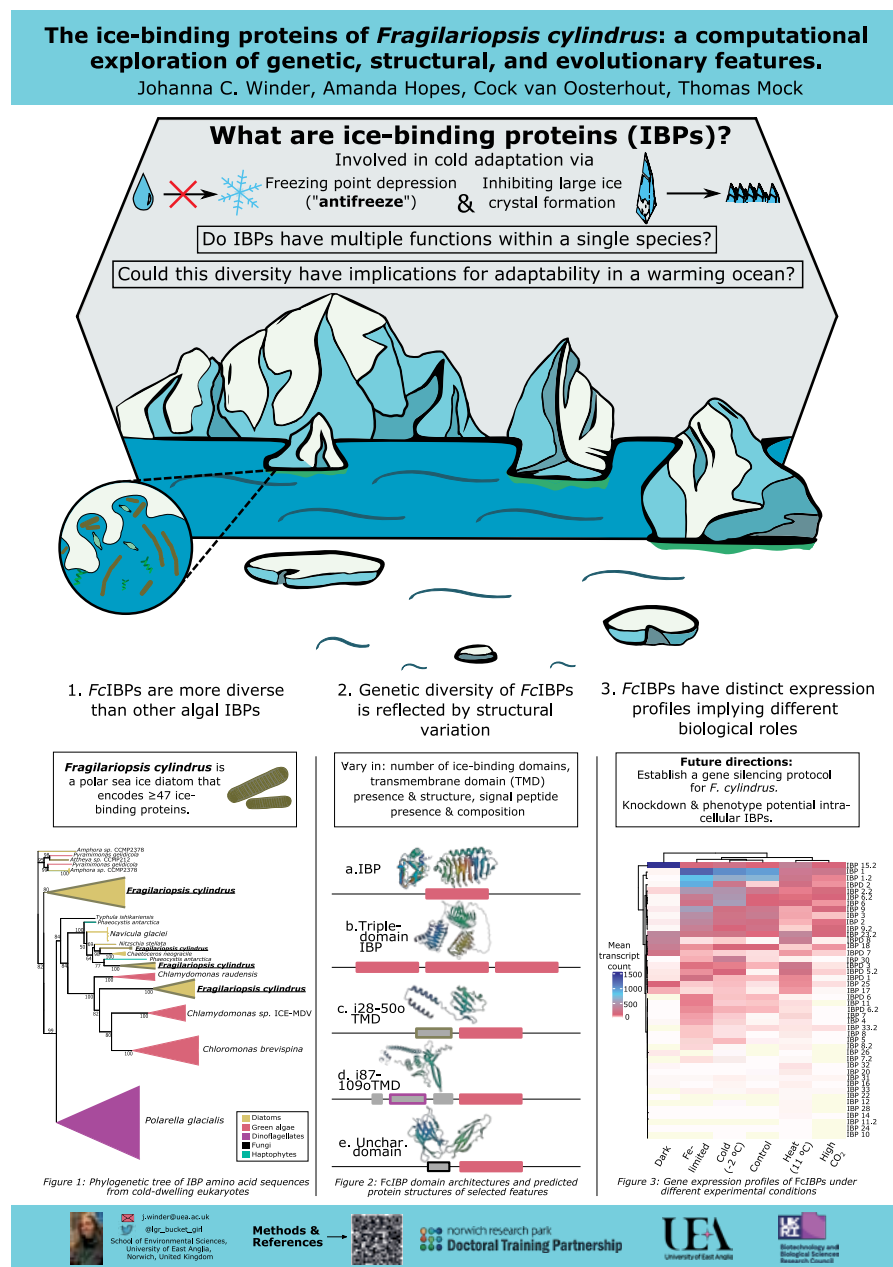
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I attended the 71st annual meeting of the British Phycological Society held in Newcastle from the 23-24th January 2023. There, I presented my poster about the ice-binding proteins (IBPs) of the polar diatom *Fragilariopsis cylindrus* (Figure 1). The genome of this organism encodes over 47 putative IBPs containing a domain of unknown function 3494 (DUF3494). The biological role of their diversity has only been minimally explored. I used a computational approach to update the catalogue of IBPs from *F. cylindrus*, predict subcellular localisation and structural motif presence, model structures, compare sequences with other polar algal species and explore expression profiles for IBP transcripts. Comparing IBP sequences between eukaryotic algae provides evidence for multiple independent origins of IBPs in *F. cylindrus* supporting acquisition of these genes via HGT. Several were predicted to be membrane bound, with the definitive presence of one nuclear localisation signal and other suggestions of plastid localisation. Structural modelling with AlphaFold revealed variation in the IBPs, including structural diversity upstream of the DUF3494 domain in many FcIBPs. Finally, expression profiles of IBPs were compared under different conditions, showing that IBPs have diverse responses to environmental changes, potentially implying different biological roles.

My experience participating in the BPS meeting was overwhelmingly positive. I enjoyed hearing about the various facets of algal research, including a glimpse into the world of macroalgal research, which I previously knew very little about! I felt that the smaller scale of this meeting created a very welcoming environment for me to ask questions and engage in talks, even when I was not an expert on a given topic. I



also enjoyed meeting other early career researchers in the field of algal research and hearing about their experiences in different research environments. I was especially intrigued by the two talks about algal pigments, which approached the topic from different, but complementary perspectives. It

served as a reminder that biotechnology and art have a meaningful intersection, especially when it comes to phyecology. Thank you to BPS for awarding me the Irène Manton Student Poster Prize (Award # 2023_BPS_0210) and for an excellent and inspiring meeting this year!

BPS Funded Projects Reports

Diatom Flora of Britain and Ireland – an update on progress to date

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The *Diatom Flora of Britain and Ireland* is a major project facilitating the identification of diatoms using their morphological features. It is led by Amgueddfa Cymru-Museum Wales' diatom curator Dr Ingrid Jüttner, funded by the British Phycological Society and has in-kind contributions from several participating experts and institutions <https://naturalhistory.museumwales.ac.uk/diatoms/contributors.php>.

The project consists of a web-based diatom flora and peer-reviewed publications providing a taxonomic review of diatoms from freshwater, brackish and subaerial habitats in Britain and Ireland <https://naturalhistory.museumwales.ac.uk/diatoms/> (1-12).

Several thousand species of freshwater diatoms occur in Britain and Ireland of which about 2800 have been formally described. However, in rivers alone, more than 4000 genetic entities were detected during a recent metabarcoding project, suggesting that there may be many diatom species in the UK that are still to be described (13). The last decade has seen many taxonomic revisions and descriptions of new species, including those in widespread genera such as *Amphora*, *Achnanthisidium*, *Eunotia*, *Fragilaria*, *Gomphonema*, *Planothidium* and *Sellaphora* (e.g. 10-11, 14-15, 16-19). Several of these taxa occur in British and Irish freshwaters and are now documented on the website, including *Planothidium galaicum* Álvarez-Blanco & S. Blanco

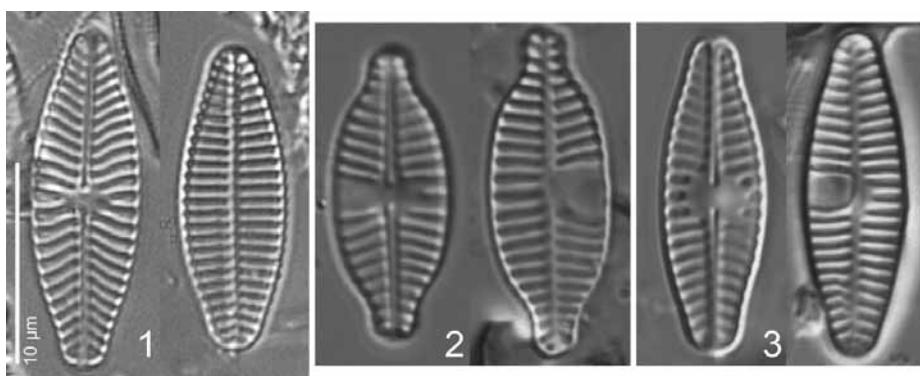


Figure 1. 1 – *Planothidium galaicum*, 2 – *Planothidium reichardtii*, 3 – *Planothidium victorii*

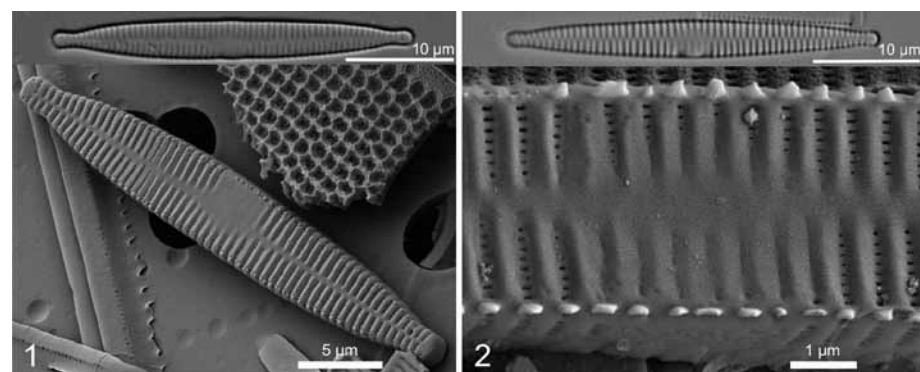


Figure 2. 1 – *Fragilaria battarbeeana*, 2 – *Fragilaria ennerdalensis*

(a species described from Spain), *Planothidium reichardtii* Lange-Bertalot & Werum (described from Germany), *Planothidium victorii* P.M. Novis, J. Braidwood & C. Kilroy (described from New Zealand, Fig. 1), *Fragilaria battarbeeana* Van de Vijver, M. Kelly, C.E. Wetzel & Ector, *Fragilaria ennerdalensis* Van de Vijver, M. Kelly, C.E. Wetzel & Ector (described from Scotland and England, respectively, Fig. 2) and *Achnanthisidium sieminskiae* Witkowski, Kulikovskiy & Riaux-Gob. (described from the Kerguelen Archipelago in the subantarctic region).

Investigations of voucher specimens and more recently collected specimens in Museum collections including type material, and species' distributions, has led to improved understanding of their taxonomy and ecology (9, 17). However, there is still a lack of agreement with respect to the application of many species' names, partly due to the adoption of broader or narrower species concepts (20), partly due to changes in species concepts (21) and force-fitting. Many poorly understood taxa described from Britain require re-examination.

Only a few of these species and their types (e.g. *Surirella pinnata* W.Smith, *S. subsalsa* W.Smith, *Tetracyclus glans* (Ehrenb.) Mills) are currently documented on the website (Fig. 3). More recently, renewed efforts have been made to study the type materials of species in difficult genera such as *Fragilaria* and *Eunotia*, including investigation of taxa in the collection of William Smith (2, 7, 16-17, 21). William Smith was one of the most prominent diatomists in the nineteenth century. His major contribution to diatom research was the publication of his *Synopsis of the British Diatomaceae* (22-23), one of the first systematic diatom monographs, and still an important resource for diatom identification. His slide collections and original type material of the species he described are kept in the Van Heurck collection, Meise Botanic Garden, Belgium (24), in the Natural History Museum in London (25) and the Royal Botanical Garden of Edinburgh. Smith's collections comprise more than 1200 samples from all over Britain, but many species in the British flora described by Smith are poorly documented and will be subject to investigation as part of the next phase of the *Diatom Flora of Britain and Ireland* project.

Diatoms are used to fulfil the UK's statutory requirements for ecological assessments of freshwaters associated with the European Water Framework, Habitats and Urban Wastewater Treatment Directives (26-30). Of the 334 species currently shown on the *Diatom Flora of Britain and Ireland* website, 118 are used in the Trophic Diatom Index (= 44% of the TDI5 species) and 53 in the Diatom Acidification Metric (= 62% of the DAM species), the UK metrics for river ecological quality assessments (31-32, DAM for acidification). Extending the documentation of the taxa used in these metrics is an ongoing task of the project and will help to reduce problems with species identification and, as a result, reduce the risk of misclassifications in ecological quality assessments and of erroneous decisions based on results of diatom analyses.

Unpolluted freshwaters such as bogs, fens, upland lakes, headwater streams and springs, can harbour high numbers of rare and endangered taxa (33). Recently, some species, typically found in these semi- or near-natural freshwaters, have been documented and illustrated on the website (Figs 4, 5), although in general, the flora of these habitats remains poorly represented. A better understanding of the flora of these unique wetlands is important for defining reference conditions. Improved documentation of these taxa can support projects that assess environmental change in threatened habitats and support ecological restoration work. This will require new investigations of unpolluted freshwater habitats, particularly those in remote upland regions and in protected areas in the coming years.

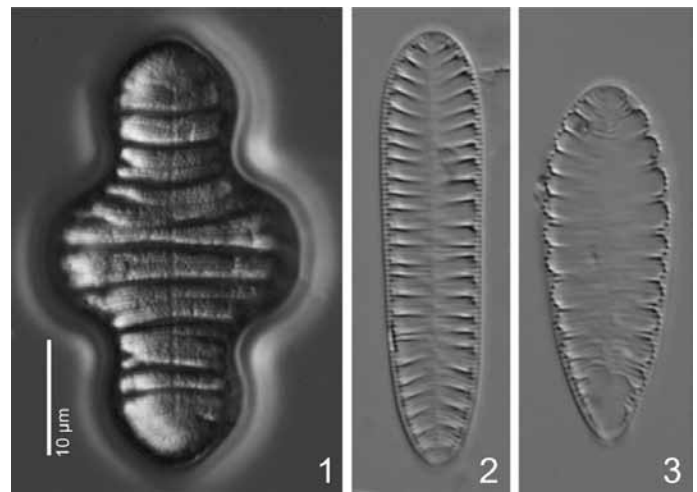


Figure 3. 1 – *Tetracyclus glans*, 2 – *Surirella pinnata*, 3 – *Surirella subsalsa*



Figure 4. *Cocconeis pseudothumensis*, *Planothidium dubium*, *Staurosirella subrobusta*, *Reimeria ovata* found at Waun Ddu Bog, Craig y Cilau, Brecon Beacons National Park, Wales



Figure 5. *Cocconeis neothumensis* found at Loch Garten, Cairngorms National Park, Scotland

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From hitchhiker to microbial symbiont in a common marine seaweed

Submitted by: Willem Stock

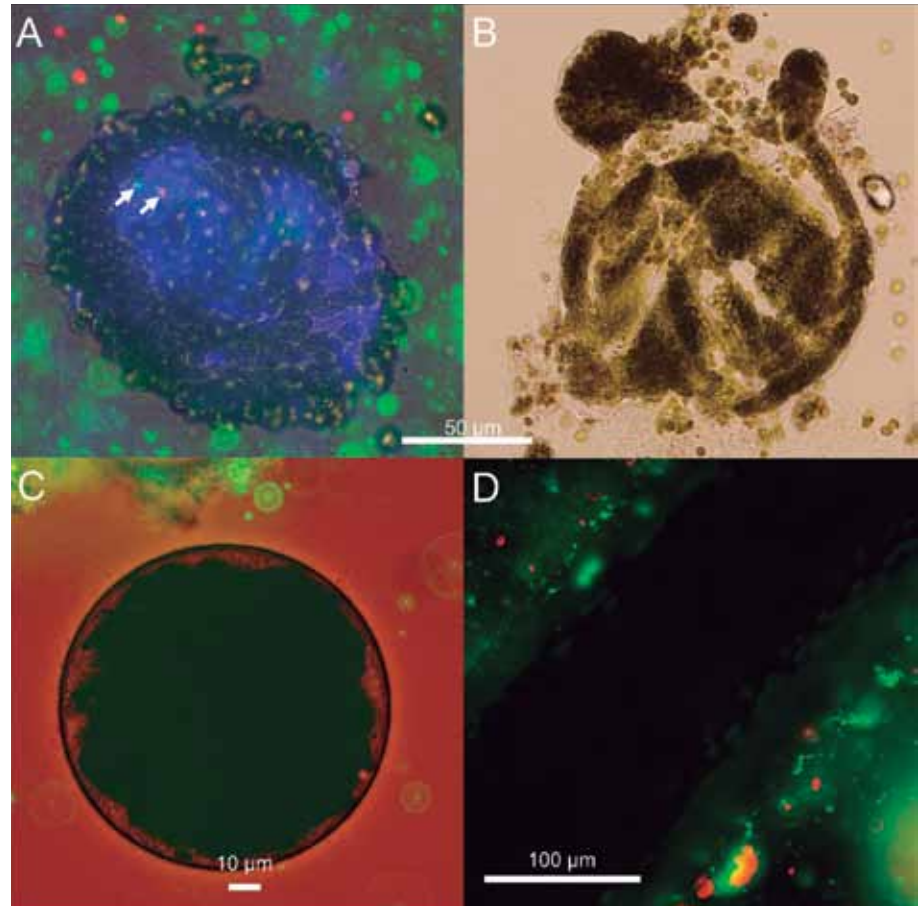
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Coevolution between a wide array of marine organisms and their endosymbionts is ongoing but few systems are as remarkable as *Bryopsis* and its endosymbiotic bacteria. *Bryopsis* (Bryopsidales, Chlorophyta) is a common siphonous marine alga containing an unusually diverse endophytic bacterial community (Hollants et al., 2011, 2013), some of which produce complex secondary metabolites that protect *Bryopsis* against predation (Zan et al., 2019). As internal cell walls are absent in the host, these bacteria live in direct contact with the hosts' nuclei and organelles.

Bryopsis has a dibiontic lifecycle with two heteromorphic alternating generations (Morabito et al. 2010). A macrothallus with the typical plumose thalli, several centimetres in size, produces anisogametes. The zygotes, resulting from fusion of the gametes, develop in a microscopic microthallus. This life stage can either directly develop into a macrothallus or produce spores that do. *Bryopsis* can also reproduce asexually through fragmentation or protoplast formation. Protoplast formation is primarily a wounding response: if the cell wall of *Bryopsis* is compromised, extruded cytoplasm rapidly aggregates into a spherical protoplast (Figure A). The protoplast is initially enveloped by a primary envelop which is later replaced by a membrane. Protoplasts can again develop into a mature alga within days.

Bacteria are vertically transmitted in *Bryopsis* through fragmentation of the algal thallus, and, since bacteria have also been observed in gametes (Burr and West, 1970), likely also through sexual reproduction. Variation between the endosymbiotic bacterial communities from different *Bryopsis* strains (Hollants et al., 2011) indicates that there should also be



Caption: Figure 1. A-D: Tracing bacteria in *Bryopsis* during protoplast formation. (A) Extruded *Bryopsis* cytoplasm is aggregating into a spherical body within minutes. A bacterium and a bead are visible in the spherical body (white arrows). (B) A disintegrating protoplast still partly surrounded by the ruptured primary envelope. (C) A one day old protoplast with an intact membrane. No bacteria or beads are visible within the protoplast. (D) An intact *Bryopsis* filament incubated with fluorescent bacteria and beads. Bacteria formed a biofilm around the filaments but were never observed within it.

opportunities for environmental bacteria to enter *Bryopsis*. We hypothesised that protoplast formation could be providing a window of opportunity for surrounding bacteria to become internalised by *Bryopsis*. In this project, funded by the BPS Project Award, we set out to validate our hypothesis.

In order to test if bacteria are engulfed during protoplast formation, we needed to be able to track them throughout the process. We there-

fore decided to use fluorescent bacteria to ease the in vivo tracing. Creating such bacteria proved difficult. We initially attempted to transform bacteria that naturally occur in *Bryopsis* through natural conjugation. We therefore supplied a plasmid with a gfp-reporter gene, that induces green fluorescence, in addition to a gene which confers kanamycin resistance (Bryksin and Matsumura, 2010) to a freshly prepared extract of *Bryopsis*. Bacteria seemed to very rarely take up the plasmid and express both

genes correctly. As several variations on this approach did not improve success rates, we decided to continue with bacterial strains from various collections that are already constitutively expressing gfp.

The gfp-tagged bacteria were supplemented to the seawater surrounding the protoplasmic masses. Red fluorescent polystyrene latex beads were added as control. The uptake of fluorescently labelled bacteria and beads was monitored by means of fluorescent microscopy (Figure 1. A,B,D). All bacterial strains as well as the beads were frequently assimilated into the extruded cytoplasm. However, no beads or bacteria were present in the membrane enveloped protoplasts when we observed them the next day. Detailed observations showed that the presence of bacteria and beads in extruded cytoplasm did not prevent aggregation into protoplasts. However, the primary envelope of these protoplasts disintegrated shortly after it was formed (Figure 1.B). From these observations, we conclude that the formation and particularly the maturation of the protoplast seems to be a tightly regulated process. As the presence of bacteria in the protoplast impedes the protoplast from developing into a new vegetative thallus, it is unlikely that colonisation of the protoplast commonly results in novel additions to the endosymbiotic community of *Bryopsis*. This does not exclude the process from being an opportunity of bacterial acquisition as bacteria might escape detection under specific conditions. Future research focussed on how the bacteria present inside *Bryopsis* manage to evade host immune responses will hopefully shed new light on this hypothesis.

This work was made possible with funding provided by the British Phycological Society (BPS award number 2021_BPS_0031). WS is funded by the fund for scientific research Flanders (FWO-1252821N). We would like to acknowledge Dr. Olivier Leroux for his assistance with the microscopy and Dr. Luis Jesus Linares-Otoya, Dr. Martine Berger & Brigitte Van Moffaert for kindly providing us with fluorescent bacterial strains.

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Slimy or not slimy: Feeling the way towards using macroalgal assessment in citizen science

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Introduction

Spatiotemporal gaps in water quality data and a lack of public participation are recognised as significant issues in environmental monitoring. Citizen science is an opportunity to address both problems. The Rapid Assessment of Periphyton Ecology in Rivers (RAPPER) is a bioassessment method developed by Martyn Kelly and colleagues, designed for use by non-specialists. The impetus for developing the method revolved around concerns that new monitoring methods are becoming increasingly complex (Kelly et al., 2016). All bioassessment methods have a degree of uncertainty due to the inherent complexity of freshwater ecosystems, but if monitoring methods are slow, specialist and resource intensive, reducing uncertainty by increased monitoring could be costly (Kelly et al., 2009; Harris and Heathwaite, 2012; Kelly et al., 2016). RAPPER is a rapid, 'triage' method, which aims to help identify problems within a catchment by enabling more sites to be visited. Moreover, frequent RAPPER surveys at individual sites could help reduce uncertainty surrounding other assessment methods. Introducing simple, rapid methods could help achieve an effective compromise between breadth and depth in monitoring programmes (Kelly, 2014).

Whilst RAPPER was designed to be suitable for non-specialists, the need for a microscope to identify many taxa remained a barrier to implementation with citizen scientists. Last year I was tasked by the Freshwater Biological Association with the development of a simplified, citizen science appropriate version of RAPPER. The project also aimed to investigate the potential for incorporating other rapid bioassessment methods,



Left: *Vaucheria*: nutrient tolerant. Right: *Spirogyra*: nutrient sensitive.

such as the Anglers' Riverfly Monitoring Initiative, developed by the Riverfly Partnership.

RAPPER interprets risk to eutrophication by assessing the relative abundance of nutrient sensitive and nutrient tolerant taxa. Nutrient sensitive taxa are defined as macroalgal genera with adaptations to grow in low nutrient environments. Alternatively, nutrient tolerant taxa dominate in high nutrient conditions. The simplified version of RAPPER differentiates individual, or subgroups of, macroalgal genera based on macroscopic characteristics. Many genera that live in low nutrient conditions produce copious mucilage, so a slimy texture is a useful characteristic for identification. In contrast, most nutrient tolerant taxa have a distinct coarse feel. Whilst other factors such as branching were important characteristics, for this study the fundamental question in the field was: Is it slimy or not slimy?

Methods

At 19 sites across two sub-catchments of the River Ribble, the original and simplified RAPPER methods were trialled simultaneously. The selected sites had a range of nutrient and alkalinity conditions. In addition, sites had minimal channel shading and were wadable. The RAPPER method involves zigzagging along a 10m section of the channel, looking for visible growths of macroalgae. After finishing the survey, the abundances of each genus are estimated. For the simplified method, all identification was done in the field. To complete the original method, small samples of each genus found were taken back to the lab and identified under the microscope. Using the total abundances of nutrient sensitive and nutrient tolerant taxa, a site can be classified as "not at risk", "maybe at risk", or "at risk" of eutrophication.



Surveying a site for macroalgae and macroinvertebrates (Right to left: Bill Brierley, Martyn Kelly, Katrina Woodfield) (Credit: Ribble Rivers Trust)



Conducting the RAPPER methodology (Credit: Bill Brierley)

Further downstream from the survey reach, invertebrates were sampled using the standard Anglers' Riverfly Monitoring Initiative method. This method involves identifying the abundance of eight specific macroinvertebrate families from a three-minute kick sample. The target families are all indicators of good water quality.

Results and Discussion

In total 22 different macroalgal genera were observed, with the most commonly recorded genus being *Oedogonium* (84% of sites), followed by *Cladophora* (78% of sites) and *Spirogyra* (68% of sites). *Melosira* is not included in RAPPER, but was observed at nearly half of the sites, generally in high abundance.

The comparison between the original and simplified RAPPER showed promising results. At 95% of the sites, the two versions of RAPPER gave the same result. Importantly, "not at risk" sites were never mistaken for "at risk" sites and vice versa. At the one site mistakenly classified as "at risk", the presence of a nutrient sensitive taxa was concealed by an abundance of *Melosira*. It was recognised that without a microscope, the different genera within an assemblage of macroalgae may be overlooked. For example, at one site on the River Ribble, samples of what was thought to be just *Cladophora* turned out to contain 50% *Oedogonium*. Originally there were concerns that, due to the more limited number of macroalgal genera included in the simplified RAPPER method, a volunteer could visit a site and be unable to identify any of the growths present. However, this did not present an issue during the field trials; the inability to identify growths using the simplified RAPPER method did not affect the assessed status at any sites.

Simplified method	Original Method			
	Not at risk	Maybe at risk	At risk	Total
Not at risk	5	0	0	5
Maybe at risk	0	8	0	8
At risk	0	1	5	6
Total	5	9	5	19

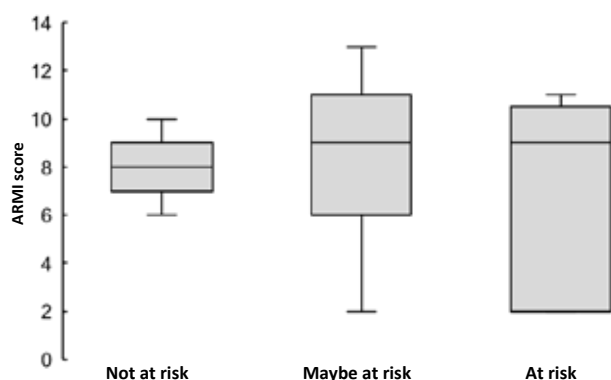
A comparison of the simplified and original RAPPER method outcomes across the 19 sites.

The accuracy of field identification was also high. For 91% of observations, the RAPPER taxa label (e.g. nutrient tolerant) assigned in the field remained the same after lab identification. The genus most misidentified was *Cladophora*, which was confused with *Vaucheria*, *Oedogonium* and *Aegagropila*. While these mistakes had limited effect on the overall RAPPER eutrophication risk, they remain important considerations when thinking about the accuracy of citizen science observations.

Comparison of the macroalgal data with the macroinvertebrate data did not show the expected results. Whilst macroalgae and macroinvertebrates will likely be responding to slightly different pressures, we generally expected that sites classified as "not at risk" using RAPPER would have the highest Riverfly scores, and those classified as "at risk" would have the lowest Riverfly scores. However, there was no significant difference in Riverfly Score between the RAPPER eutrophication risk outcomes. This was likely due to the effects of longitudinal changes in river productivity. It was observed that some upland sites that were classified as "not at risk" of eutrophication also had notably low Riverfly scores compared to lowland rivers classified as "at risk". There was a greater variation of Riverfly scores at "at risk" sites compared to "not at risk" sites, indicating that "at risk" sites were affected by

more factors, beyond longitudinal changes in productivity. For example, some “at risk” sites did have very low Riverfly scores, likely attributed to agricultural pollution. Additionally, the effect of multiple stressors (e.g. grazing, light, substrate, hydrological regime) could have altered the relationship between RAPPER and Riverfly.

However, the data indicated that macroinvertebrate analysis could provide further information about “maybe at risk” sites. For example, one “maybe at risk” site had a very low Riverfly score of 2, which could indicate that the macroinvertebrates were affected by a pressure which hadn’t affected the macroalgal community. The extended Anglers’ Riverfly Monitoring Initiative method could be a better complementary method for RAPPER. The extended scheme is potentially less reliant on macroinvertebrate abundance, includes negative indicators of water quality, and provides an additional silt and flow score, conditions that can also affect macroalgal growth. Initial observations in the field indicated that Extended Riverfly could be a beneficial addition to RAPPER, however, further fieldwork would need to investigate this.



Box plots of ARMI (Anglers’ Riverfly Monitoring Initiative) score, for sites classified as not at risk, maybe at risk and at risk of eutrophication using the original RAPPER method.

The RAPPER results were also compared with relevant WFD classification status (2019 cycle 3). Discrepancies between the WFD and RAPPER results indicated the need of more frequent monitoring using rapid methods. On a stream reported to have good macrophytes status, 80% coverage of *Cladophora* indicated that conditions had changed since the classification was made. However, the exceptionally hot and dry weather during summer 2022 likely contributed to the high cover of macroalgae seen at many sites. The temporal and spatial resolution of WFD biological operational monitoring is low. Methods such as RAPPER which can feasibly be conducted more frequently may be beneficial so that recent pollution incidents or problems are not overlooked.

I came into this project with little specific knowledge of macroalgae, allowing me to appreciate the perspective of a citizen scientist. With only one and a half days of formal training, I found the simplified RAPPER method to be easy, quick, and overall enjoyable. Nevertheless, the next challenge will be to test the method with real volunteers and take on board their opinions. The uncertainty associated with simplified RAPPER assessments, and the implications for increasing stakeholder engagement, will be important future considerations. We have plans to trial the method with volunteers in the Ribble catchment later this year.

We are grateful to The British Phycological Society (Award number: 2022_BPS_0098) for the funding to support this project. The project has been an exceptional experience for me personally, and I hope that the findings from this study are beneficial in future work.

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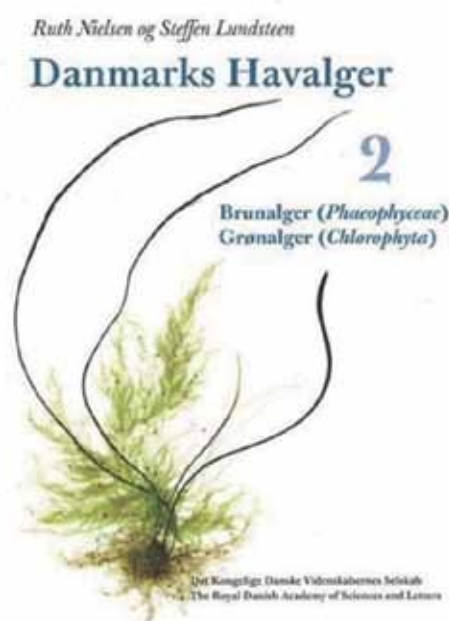
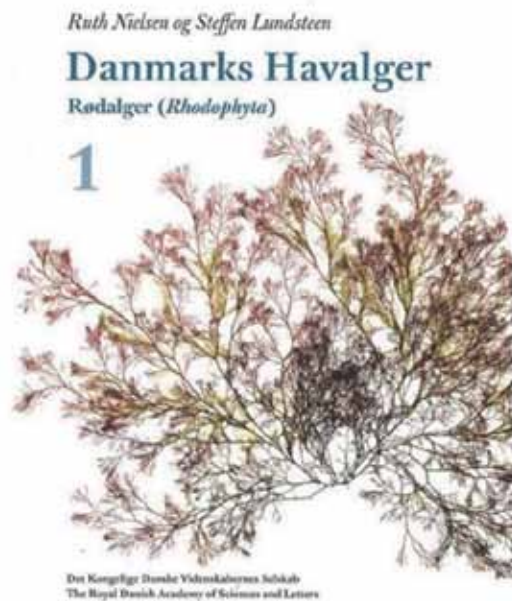
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Book Review: Seaweeds of Denmark

by Ruth Nielsen, Steffen Lundsteen and Juliet Brodie

Published by the Royal Danish Academy of Sciences and Letters

Review by: Francis Bunker



Seaweeds of Denmark is a two-volume flora originally published in Danish and now translated into English. It runs to over 800 pages, describing 165 species of red algae, 125 brown algae and 83 green algae. The red algae are described in Volume 1 and the brown and green algae in Volume 2 making this the most comprehensive Danish seaweed flora published to date. What is immediately striking about these volumes is the easy-to-read text and the way each species is illustrated with superb photographs as well as line drawings.

Many seaweed floras seem to be written by experts for experts and are hard to access if you are a student of phycology and are try to 'get into' the subject. The Seaweeds of Denmark goes a long way to address this. There is a very useful 43-page Introduction. It begins with the history of taxonomic phycology in Denmark illustrated

with photographs of some of the major players and institutions. There follows some basic ecological information on seaweed communities in Danish waters and how they change under the varied regimes of salinity and the distribution of the glacial stone reefs (there is little bedrock around Denmark). This is followed by basic taxonomic information superbly illustrated with photographs and drawings. There is information that I haven't seen before in other guides such as colour photographs showing clear differences between plastid types and distribution of pyrenoids in cells. There are photographs of seaweed reproductive structures and easy to read descriptions of seaweed classification and the red, green and brown seaweed groups. There is a simple explanation of what is meant by a type specimen including definitions of terms such as holotype, lectotype, neotype and epitype.

Material is provided on other books which are useful to supplement these volumes. There is also information on seaweeds as a source of food, collecting seaweeds and algal cultures.

The main body of the book describes the species which are arranged to agree with current systematic understanding. Useful keys are provided for all the major groups. Species descriptions are concise but present enough key information for identification (together with the photographs). The current Latin name is given together with the authorities (although the Introduction provides a caveat that names may change in the future following further molecular investigation into relationships between species). A common name is then given with the list of common names building on those adopted in the Seasearch Guide to Seaweeds of Britain and Ireland. There are para-

graphs on Appearance, Reproduction, Seasonal Variation and Habitat each of which provides concise information on the species. A useful Comments paragraph provides supplementary information about a species. Lastly there is a References section, where the most current references relating to a species is given (but not an exhaustive bibliography).

At the end of each of the major sections there are ambitious keys to the genera of red, brown, and green seaweeds. Sections conclude with maps showing the distribution of each species around the coast of Denmark. There

is also a Reference section after each of the major groups. For those not familiar with taxonomic descriptive terms, there is a useful Glossary of Terms at the end of Volume 2.

This book provides a major step forward in the production of truly useful field guide come reference books. The photographs alone are an invaluable resource. Whereas the seaweed flora of Britain and Ireland is more diverse than the Danish (with 656 species as opposed to 373), this book will be a valuable addition to the libraries of any field worker or seaweed taxonomist working in the Northeast Atlantic. In summary this book is highly recommended.

PHYLUM: RHODOPHYTA - RED ALGAE

SCL DAN. B. 10

adaxial side of the opposite branches. Carpogonial branches form on the outer (abaxial) side of the opposite branches near the apex. Gonimoblasts have several rounded lobes. The cruciate tetrasporangia on stalks are in series on the adaxial side of the opposite branches. Their stalks may have branches with more tetrasporangia appearing as small clusters. The sporangia are ellipsoid, 32-47 µm in height and 25-33 µm in width.

Seasonal variation: Basal systems, completely overgrown by epiphytes, and probably overwintering observed in January-February with a few upright cells.

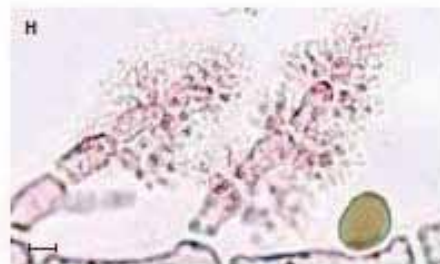
Well-developed individuals collected in April-October. Antheridia recorded in June-September, gonimoblasts in August-September and tetrasporangia in June-August.

Habitat: At shallow water, 1 m depth on a concrete wall in the harbour, Frederikshavn and at Thyholm. Otherwise in deeper water, epiphytic on other algae, epizoid on Common Whelk (*Buccinum undatum*), bryozoans and hydroids, 5-20.5 m depth.

References: Athanasiadis (1986), Maggs & Hommersand (1993), Rosenvinge (1923-24, *Anthamion plumula*).



G: *Pterothamnion plumula*. Gland cell. Hirsholm, drift, 25.5.2010. Scale 10 µm.



H: *Pterothamnion plumula*. Antheridial branches and a gland cell. Scale 10 µm. H, J: Boblertev at Nordre Rønner, Læsø, 10 m, 17.8.2004.



I: *Pterothamnion plumula*. Female gametophyte with two carpogonial branches, carpogonia (c) and trichogynes (arrows). Tønneberg Bank, 13 m, 20.8.2001. Scale 10 µm.



J: *Pterothamnion plumula*. Gonimoblast with rounded lobes. Scale 50 µm.



K: *Pterothamnion plumula*. Cruciate tetrasporangium on branched stalk. Munkegrunde, 11 m, 4.8.1994. Scale 10 µm.

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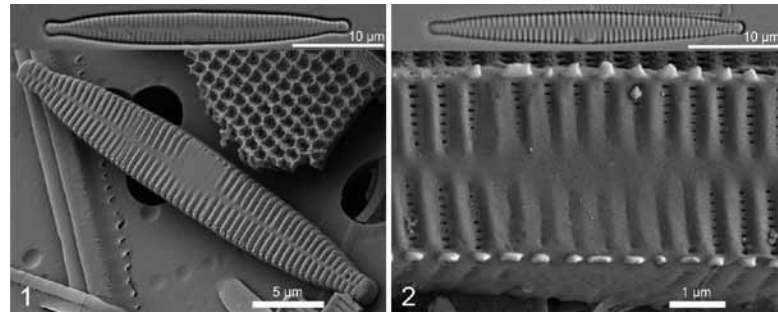
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