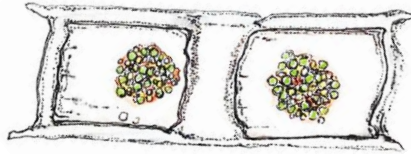
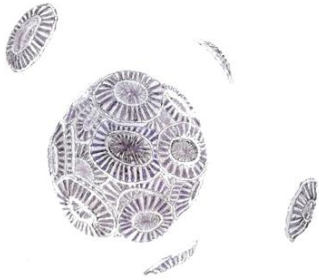
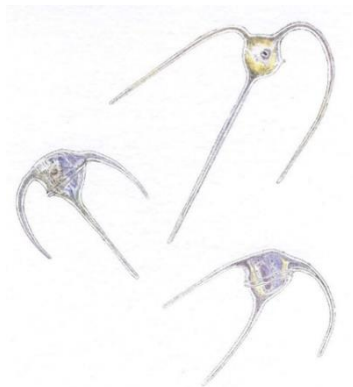
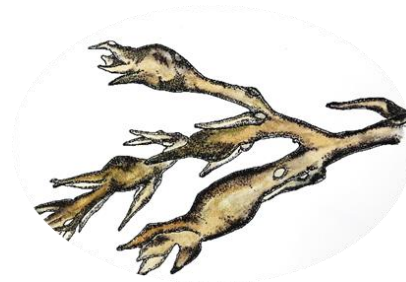
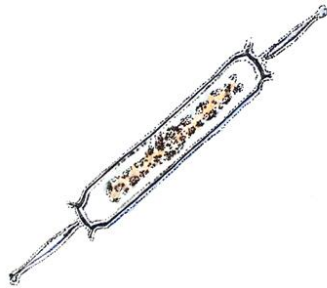


British
Phycological
Society

Understanding and using algae



The 68th British Phycological Society Meeting 6 – 9 January 2020



Conference Handbook



UNIVERSITY OF
PLYMOUTH

PML

Plymouth Marine
Laboratory



Incorporated by
Royal Charter

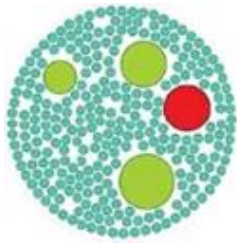
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Artwork kindly donated by local artist Debby Mason

For more information and to view more work from Debby, please visit her exhibition stand during the conference and her website: www.debbymason.com





**British
Phycological
Society**
Understanding and using algae

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WELCOME TO BPS 2020

Welcome to the *British Phycological Society* 2020 Winter Meeting (#bps2020 on Twitter), and to Plymouth which is celebrating the 400th anniversary of the journey of the *Mayflower* to the 'new world' of America.

The Scientific Organising Committee: (Clare Widdicombe, Mike Allen, Mahasweta Saha from *Plymouth Marine Laboratory*, Clare Ostle, Colin Brownlee Dan Smale, Gerald Boalch from the *Marine Biological Association*, plus Lina Rasmusson and I from the University of Plymouth) is very impressed by the diversity of phycology that will be presented as well as the quality of abstracts submitted for the **Irene Manton Prize** for the best oral paper by a postgraduate student, and the **British Phycological Society Student Poster Prize**, for the best poster by a postgraduate or undergraduate student. Students are invited to attend these talks free of charge.

Volunteer helpers will be around to assist and will make themselves conspicuous. Many thanks to our sponsors The British Phycological Society, The Company of Biologists and The Marine Biological Station, Varicon aqua, AlgaeCytes, Taylor & Francis publishers, the University of Plymouth Marine Institute, Plymouth Marine Laboratory and Isle of Harris Distillers Ltd. This support has enabled us to invite speakers from all over the world to share insights into pure and applied aquatic plant and algal biology.

Please come along to The British Phycological Annual General Meeting which will be at 17:00 on Tuesday 7 January and is open to all members of the Society, and spread the word about the Public Lecture at 16.00 on Wednesday 8 January.

Prof Jason Hall-Spencer (President Elect, British Phycological Society)

STUDENT ORGANISING COMMITTEE

Our friendly and hardworking student volunteers are helping out before and during the whole meeting!



Nora Salland (MBA)



Alissa Bass (MBA and UoP)



Barry Pettifor (UoP)



Harry Catherall (MBA)



Cat Wilding (MBA)



Luka Wright (UoP)



Emilie Courtecuisse (PML)



Patrick Downes (PML)



Clare Marshall (MBA)
Chair of the committee



Guillaume Signoret (MBA)

CONFERENCE INFORMATION

Programme

Some printed conference handbooks and programmes will be available at the conference desk.

Conference Venues

The BPS 2020 Conference will start at the Marine Biological Association on the 6th January and then move to the Roland Levinsky Building at the University of Plymouth on the 7th January. There is an optional boat trip and/or University Marine Station visit in the afternoon on the 9th January.

Registration

Delegates who wish to register on Monday 6th January can do so at the Marine Biological Association from 15:30.

Located on the Ground Floor of the Roland Levinsky Building, the Registration and Information Desk will be open throughout the conference from 08:30 – 17:30 daily. Members of the University of Plymouth Events Team will be on hand to assist with information about the conference and general information about Plymouth throughout the event.

Student helpers will be available to help with directions, programme and poster questions, audio-visual, computer and room issues.

Campus Wi-Fi

Select “**Guest Wifi UoP**” on your Wi-Fi enabled laptop, tablet or phone to enable you to access whilst on main campus. Some delegates may be able to access the internet via their Eduroam account

Scientific Session Protocol

It is generally accepted to photograph aspects of presentations for own personal use (similar to taking notes). However, please check with the authors if you are planning to share content via social media or in any other way, and watch out for no twitter signs on slides. This applies especially where authors are presenting unpublished data. Please also ask authors if you wish to audio or video record any of the information presented during oral sessions or on posters.



Having said this, we are very keen to have a conversation on social media using **#bps2020**. Please share your own thoughts, observations and comments there with the BPS community, and post snapshots of the conference as long as the authors agree to it.

Oral Presentations and IT requirements

Due to the high number of submissions we have had to (unfortunately) limit speakers to strict time slots. Timings will be controlled by the session chairs.

All University of Plymouth classrooms and lecture theatres are equipped with Windows 7, running office 2010 including PowerPoint, data projectors with a VGA connection, power point clickers and full internet access, the lecture theatres are also equipped with lectern and roving/lapel microphones. If you wish to use your own laptop or MAC please ensure you have agreed this with the organising committee prior to the conference, as some devices including MAC's can be problematic when connecting in the classrooms.

Please report to the Registration and Information desk with your presentation on a USB memory stick as soon as possible where a member of staff will take a copy of your presentation and pre-load this onto the computer in your presentation room ahead of your session.

Poster Presentations

On arrival please bring your poster to the Registration and Information desk, where you will be provided with poster board fixings to mount your posters on their designated numbered board, which will be displayed throughout the conference on the ground floor of the Roland Levinsky Building.

A poster session will be held with refreshments provided on Tuesday 7th January between 18:00 – 19:30.

All poster boards can mount A1 landscape and A0 portrait poster only.

Refreshments

To enhance networking opportunities, drinks, snacks and buffet lunches will be provided on the ground floor of the Roland Levinsky Building on each day of the conference. Seating is available in the café area located on the first floor of the building. Additional café facilities are available on campus.

Access

There are toilets and disabled toilets located on each floor of the building. Lifts and staircases are available to all floors and Roland Levinsky Building Lecture Theatres all have wheelchair access.

Fire exits are through the main entrances/exits to the building. There are also a number of emergency exits on the ground floor, please follow the green and white signs to the nearest exit in the event of a fire alarm sounding.

The fire rendezvous points for the Roland Levinsky Building are as follows: for the WEST side of the building – congregate at Smeaton Building east end (facing Scott Building). For the EAST side of the building – congregate at LINK South West End. People with disabilities should, if possible, exit to the North side of the building in order to avoid the steps.

Smoking is prohibited in all common use areas such as classrooms, laboratories, offices and lecture theatres. Smoking areas are located outside all buildings. It is prohibited to smoke within 5 metres of a building.

All security personnel are trained first aiders; please contact the registration/information desk in the first instance if you require assistance.

Health and Safety Information

If you have an emergency and need to contact someone during the conference, here are some useful numbers:

University of Plymouth Main Reception:	01752 588444
First Aid & Lost property (Security):	01752 588400
On-site Pharmacy (Boots):	01752 224503

Photography

There may be instances throughout the conference when the University of Plymouth official photographers or BPS amateur photographers will be taking pictures for PR and marketing purposes. In some instances you may have been asked in advance for your permission, and in others you may be asked on the day. If you do not wish to appear in any photographs please make this known to the photographer or the conference organisers.

Cash Machine

There is a free to use ATM situated just outside the Roland Levinsky Building, which is available 24 hours a day. In addition there is a Santander Branch in the Smeaton Building.

Car Parking

At the University of Plymouth, we are serious about sustainability. In line with our green travel plan, we encourage people to find alternatives to using cars (unless it is essential due to mobility issues). Parking on campus is highly restricted.

If you are a blue badge holder we will endeavour to offer parking at all times, please let the Registration and Information Desk know on arrival.

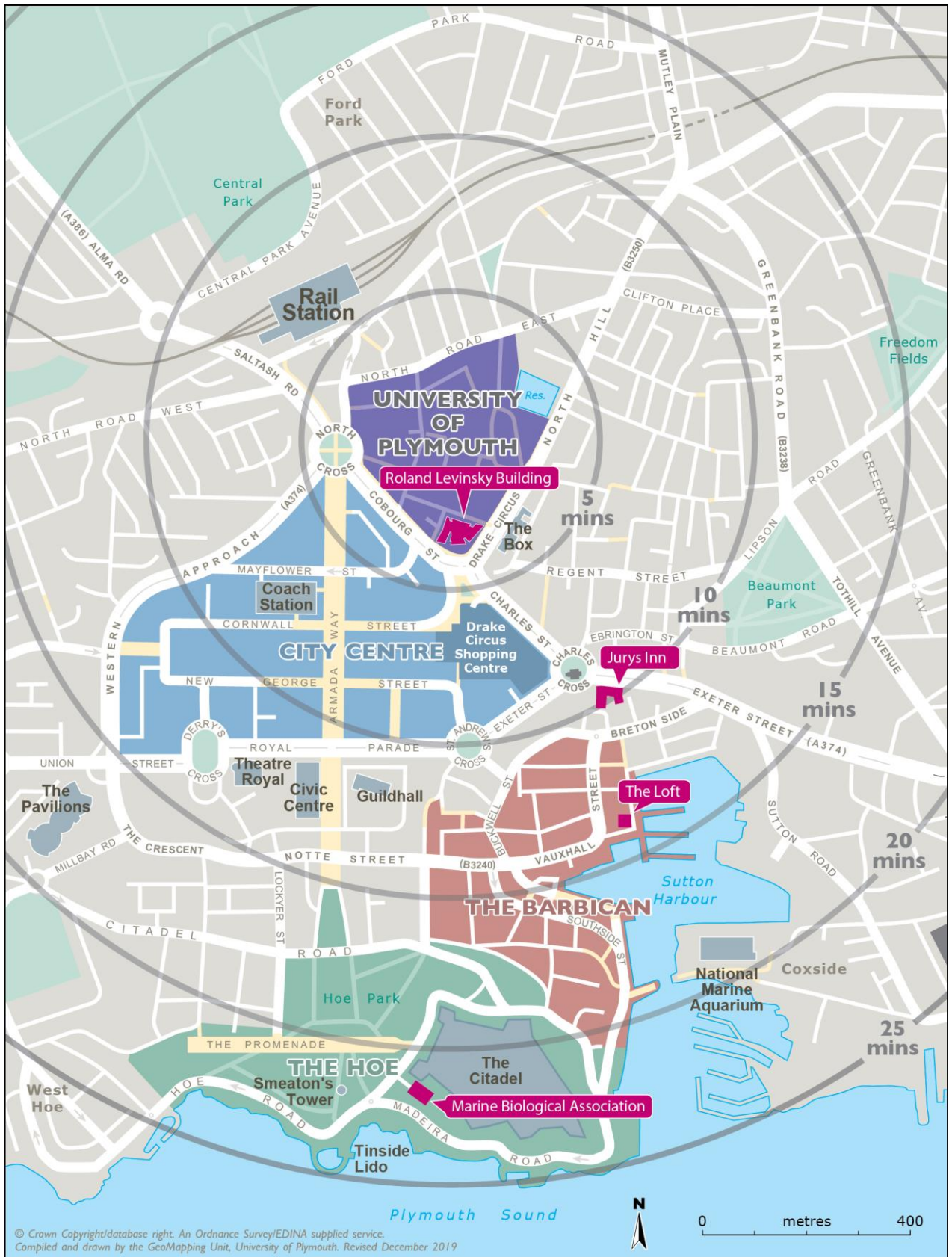
There are plenty of car parks in the city centre within walking distance of the University. A full list and maps are available from the Plymouth City Council website. The nearest are Plymouth Train Station, Mayflower House Court, Mayflower Street East and Regent Street. Your hotel may offer parking at a reduced rate, please ask your individual accommodation provider for further information.

Local Transport

Plymouth is a compact city and therefore easy to walk to various destinations during your stay. Hackney Carriage Taxis are available at the Train Station and around the City Centre and local buses are frequent. Please ask at the Registration and Information Desk if you require further information about buses, taxis or the Plymouth Park & Ride service.

Need-A-Cab	44 (0)1752 666222
Towercabs	44 (0) 1752 252525

PLYMOUTH WALKING DISTANCE



PLYMOUTH: BRITAIN'S OCEAN CITY



1 Independent Quarter



2 The Piazza



3 Royal Parade



4 Millbay



5 The Sound



6 The Hoe



7 Mayflower Steps



8 Plymouth Gin



9 Ai Fresco dining



10 Historic Barbican



11 Modern Barbican

Plymouth Map

with key attractions and distances

All distances are timed in minutes walking the shortest and most direct route from the Piazza. All times are approximate depending on individual speed of walking. The times are shown like this example: **11**  **7**





12 Drake Circus



13 Cornwall Street



14 City Museum and Art Gallery



15 Roland Levinsky Building

PROGRAMME

PROGRAMME (LT1, LT2 = Lecture Theatres 1 & 2, JCC = Jill Craigie Cinema)

Monday 6th January 2020	
15:30-18:00	Registration, Marine Biological Association (MBA), Plymouth PL1 2PB
15:30-17:30	BPS Council Meeting (Council Members Only). Wolfson Room, MBA
17:30-18:30	Student icebreaker. Common Room, MBA
17:30-19:30	Buffet reception, Resource Centre, MBA

Tuesday 7th January 2020		
8.30-9:00	Registration, Roland Levinsky Building, Plymouth PL4 8AA	
9:00-9.10	Welcome by Jerry Roberts, Deputy Vice-Chancellor, University of Plymouth. LT1	
9:10-9:35	Invited Lecture Grégory Beaugrand: Responses of phytoplankton to climate in the North Atlantic Ocean: past, present and future. LT1	
9:35-9:45	The history of phycology in Plymouth by Gerald Boalch. LT1	
9:45	Manton Prize Session 1 Convener Pippa Moore and Nora Salland LT1	
9:45-10:00	Albert Pessarrodona: Global miniaturisation of temperate marine forests. LT1	
10:00-10:15	Rachel Parkes: Differential responses of <i>Stauroneis</i> sp. (Bacillariophyceae) exposed to varying conditions post-stationary phase. LT1	
10:15-10:30	Tom Rossiter: Hyperspectral mapping of <i>Ascophyllum nodosum</i> in western Ireland. LT1	
10:30	Tea break, exhibition, posters	
10:50-11:35	2 min poster and exhibit pitches. LT1	
11:35-11:50	Anna Busch: A UV-inducible sunscreen pigment found in the extracellular mucilage of aerophytic green algae (Conjugatophyceae). LT1	
11:50-12:05	Emilie Courtecuisse: Novel fluorescence techniques to discriminate cyanobacteria in mixed phytoplanktonic assemblages. LT1	
12:05-12:20	Daniel Liesner: Local differentiation in heat response of <i>Laminaria digitata</i> at the range edges. LT1	
12:20-12:35	Alexandra Kinnby: Idiosyncratic responses to increased salinity stress in populations of <i>Fucus vesiculosus</i> . LT1	
12:35-12:50	Kiara Franke: Contrasting temperature performance of two co-occurring digitate Arctic kelp species. LT1	
12:50	Lunch	
13:30-13:55	Special session 1 Invited lecture Irene Olivé: Seagrass meadows – sensitive but mighty sentinels in a changing world. Introduced by Heidi Burdett. LT2	
13:55	Session 1: Hidden forests. Conveners Dan Smale and Heidi Burdett	Session 2: Algal interactions. Conveners Joe Taylor and Michael Cunliffe
13:55-14:15	Kathryn Schoenrock: Kelp forests of Ireland: diversity, productivity and resilience to change. LT2	Sandra Lage: Metabolomic and physiological interactions between a cyanobacterium and a diatom: what regulates a coexistence? Levinsky Room

14:15-14:35	Laura Cappelatti: Functional alpha- and beta-diversity of seaweeds across the rocky intertidal elevation gradient. LT2	Félix Cicéron: Optimization of recombinant antibody production in the diatom <i>Phaeodactylum tricornutum</i> . Levinsky Rm
14:35-14:55	Dan Smale: Climate-driven shifts in kelp forest structure: implications for productivity, biodiversity and resilience. LT2	Janina Brakel: A model system to improve our understanding of red algae - oomycete interaction. Levinsky Room
14:55	Tea break, exhibition, posters	
15:20-15:40	Nick Stewart: The Clones/Magheraveely Lakes - how water quality decline is reflected in charophyte lakes. LT2	Davis Laundon: Evidence supporting the 'healthy herd hypothesis' in a marine protist-diatom interaction. Levinsky Room
15:40-16:00	Lina Rasmusson: Arctic coralline algae. LT2	Carly Daniels: Establishing environmentally and commercially sustainable techniques for farming seaweed. Levinsky Room
16:00-16:25	Special session 1 Invited lecture Pippa Moore: Changes in the structure and functioning of kelp forests in a warmer world. Introduced by Dan Smale. LT2	
16:25-16:50	Special session 2 Invited lecture Sebastian Hess: First insights into the molecular mechanisms involved in the perforation of algal cell walls by microbial protoplast feeders. Introduced by Joe Taylor. LT2	
17:00-18:00	Annual General Meeting of the BPS (open to all BPS members). Levinsky Room	
18:00-19:30	Poster session and Taylor & Francis sponsored reception. Opening words by Hennie Thomson.	

Wednesday 8th January		
8:30-9:00	Registration, Roland Levinsky Building, Plymouth PL4 8AA	
9:00-9:25	Special session 2 Invited lecture Fabrice Not: Plankton Photosymbiosis. Introduced by Michael Cunliffe. LT2	
9:25	Special Session 2: Algal interactions. Conveners Joe Taylor and Michael Cunliffe. LT2	General Phycology Session. Conveners Irene Olivé and Guillaume Signoret. JCC
9:25-9:45	Roshni Paul: Bioenergy production from <i>Saccharina latissima</i> through anaerobic digestion. LT2	Glenn Wheeler: Physiological responses of marine diatoms to osmotic stress. JCC
9:45-10:05	Georgina Andrews: A microalga and its microbiome: Diversity, variability and not just a question of B12. LT2	Alison Taylor: Phagocytosis and the digestive vacuole of diploid calcifying coccolithophores. JCC
10:05-10:25	Juliet Brodie: Towards understanding the prokaryote microbiome composition and impact on carrageenophyte red algae. LT2	Katherine Helliwell: A novel Ca ²⁺ signalling pathway co-ordinates environmental phosphorus sensing and nitrogen metabolism in marine diatoms. JCC
10:25-10:45	Georgia Ward: Exploring eukaryotic diversity associated with carrageenophyte red algae: a study of <i>Chondrus crispus</i> . LT2	Jessica Walker: Oriented occlusions in <i>Acantharia</i> spicule growth. JCC
10:45-11:05	Dedmer Van de Waal: Ecological stoichiometry of phytoplankton parasites. LT2	Hennie Thomson: How to Get Published in BPS journals and Widening Impact of research. JCC
11.05	Tea break, exhibition, posters	

11:30	Manton Prize Session 2 Conveners Alexandra Campbell and Clare Marshall. LT2	
11:30-11:45	Jack Dickenson: Characterising the role of NADPH oxidase in marine diatoms. LT2	
11:45-12:00	Regina Kolzenburg: The effect of climate change on coastlines, a case study of <i>Corallina officinalis</i> . LT2	
12:00-12:15	Oloyede Adekolurejo: Sensitivities of key freshwater species to environmentally relevant exposures of microcystin LR. LT2	
12:15-12:30	Erin Meyer: Sr in coccoliths of <i>S. apsteinii</i> : partitioning behaviour in coccolith morphogenesis. LT2	
12:30-12:45	Carla Greco: Under the ice: microbial mats of Lake Untersee, Antarctica. LT2	
12.45	Lunch	
13:30	Special Session 3 – Impact of climate change on marine and freshwater algae. Conveners Mahasweta Saha and Dedmer Van de Waal. LT2	General Phycology Session. Conveners Chris Yesson and Emilie Coutecuisse. JCC
13:30-13:50	Friedrich Kleiner: Temperature sensing in diatoms: cold shock and Ca ²⁺ signalling. LT2	Mónica Michel-Rodriguez: Wavelength-dependency of photosynthesis on coastal seas: insights for chromatic light climate change. JCC
13:50-14:10	Amanda Burson: Impact of increased ice-sheet melt on the phytoplankton community within Greenland's fjords. LT2	Alastair Skeffington: An accurate long-read genome and transcriptome of <i>Emiliana huxleyi</i> . JCC
14:10-14:30	Mahasweta Saha: Salinity and time can alter epibacterial communities of an invasive seaweed. LT2	Linda Medlin: Reanalysis of the Theriot <i>et al.</i> (2015) 7 Gene dataset using multiple outgroups. JCC
14:30-14:50	Gerald Langer: Life cycle phase specific responses of <i>Coccolithus braarudii</i> to light intensity and nutrient limitation. LT2	Donal McGee: Challenges and opportunities in developing a sustainable algal biorefinery. JCC
14:50	Tea break, exhibition, posters	
15:10-15:30	Christopher Williamson: Algal photophysiology drives darkening and melt of the Greenland Ice Sheet. LT2	Christine Campbell: International algal culture collections: essential services for 21st century phycology. JCC
15:30-15:55	Special Session 3 Invited lecture Alexandra Campbell: Climate change and diseases of seaweeds, microbiome manipulations and restorative aquaculture. LT2	
16:00-17:00	Public Lecture and Presidential Address by Graham Underwood: Thin films of Life and the challenges of changing environments. LT1	
19:30-23:00	Conference Dinner & Dance. The Loft, Sutton Harbour, Plymouth PL4 0DN	

Thursday 9 th January 2020		
9:00-9:20	Registration, Roland Levinsky Building, Plymouth PL4 8AA	
9:20-9:30	Varicon Aqua: Making Algae Easy. LT2	
9:30-9:55	Session 4 The Use of Algae as Biomonitors in Freshwater and Marine Systems. Conveners Martin Wilkinson and Juliet Brodie. LT2 Martyn Kelly: Setting nutrient thresholds to achieve Good Ecological Status in surface waters. LT2	
9:55-10:20	Session 4 Invited lecture Mike Best: Limiting lifestyles - how plankton lifeforms are changing in UK marine waters. LT2	
10:20	Session 4 continued	General Phycology Session. Conveners Sebastian Hess and Alissa Bass. JCC
10:20-10:40	Joanna Wilbraham: Conservation challenges for a microscopic world: Documenting desmids. LT2	Anne Jungblut: Drivers of biodiversity in phototrophic microbial mats and bacterioplankton in Antarctic freshwaters. JCC
10:40-11:00	Tea break, exhibition, posters	
11:00-11:20	Owoyemi Elegbeleye: Phytoplankton assemblage in a tropical harbour: microscopy versus chemotaxonomy. LT2	Klaus Valentin - Limits of short and long term acclimation in the Arctic diatom <i>Melosira arctica</i> . JCC
11:20-11:40	Rowena Stern: Using historic samples to uncover Harmful Algal species niche preferences. LT2	Lin Baldock: <i>Flabellia petiolata</i> in England - cryptic long established species or recent colonist? JCC
11:45-12:05	Session 4 Invited lecture Chris Yesson: Methods for monitoring habitat-forming seaweeds. LT2	
12:05-12:30	Hiroshi Kawai: Taxonomic study of Japanese <i>Ecklonia</i> and <i>Eisenia</i> (Laminariales, Phaeophyceae). LT2	
12:30	Get own lunch	
13:30-15:00	University of Plymouth Marine Station tour and look at local diver-collected seaweeds. Sign-up sheet at registration.	
13:30-15:00	Plymouth Sound phytoplankton sampling aboard a research vessel. Sign-up sheet at registration, 10 people max.	

SPECIAL SESSIONS

1. Hidden forests: the structure and function of macrophyte-dominated habitats and communities under natural variability and anthropogenic stress

Convenors: Drs Dan Smale and Heidi Burdett

Outline: Aquatic macrophytes (e.g. kelps, seagrasses, maerl, stoneworts, etc) often function as foundation species by providing extensive biogenic habitat that underpins high primary and secondary productivity and modulates environmental conditions. Macrophyte-dominated habitats are of significant ecological and socioeconomic value, yet the distribution and integrity of these systems is increasingly affected by a range of concurrent stressors, including physical disturbance, decreased water quality and climate change. This symposium will explore recent advances in our understanding of macrophyte-dominated habitats and communities, incorporating fundamental biology, ecological patterns and processes, biogeochemistry and management and conservation. By sharing knowledge gained from diverse habitat-types and across biological scales, we aim to improve our collective understanding of the value and resilience of these critical habitats. We invite submissions from those working on habitat-forming macrophytes in both freshwater and marine ecosystems.

2. Algal interactions across the tree of life - from the open ocean to industrial applications

Convenors: Drs Joe Taylor and Michael Cunliffe

Outline: Contemporary molecular tools have revolutionised our understanding of aquatic biodiversity, with many previously un-described interactions involving algae identified. New symbionts, parasites and pathogens of micro- and macro-algae are being frequently discovered. This symposium will explore the range of biotic interactions (symbiosis, commensalism, pathogenicity and parasitism) within and between algal systems, including interactions that are essential in maintaining biodiversity and healthy ecosystems. We will bring together micro- and macro-algae researchers with an emphasis on interdisciplinary exchange. Some focus will be given to how 'omics (metabarcoding, meta/genomics, meta/transcriptomics, meta/proteomics), cell biology and advanced microscopy can be combined to explore algal interactions across the tree of life, including, with fungi, protists, bacteria and viruses. Focus will also be given to how these interactions can be utilised, or mitigated against, in applied systems, such macroalgal farming for food and biomass, microalgal production and the control of harmful or nuisance algal blooms. The symposium welcomes submissions from researchers studying biotic interactions in all algal systems from the individual cell to algal microbiomes, up to whole ecosystems and community ecology.

3. Impact of climate change on marine and freshwater algae

Convenors: Drs Mahasweta Saha, Dedmer van de Waal

Marine and freshwater macrophytes, microalgae and cyanobacteria are dominant primary producers in aquatic systems worldwide. These ecosystem engineers provide a suite of ecologically valuable services, form the base of food webs, and play a key function in the global carbon cycle. However, rapid climate change is a major threat to Earth's biodiversity and ecosystem functioning. Ongoing global change is expected to increase pCO₂ and temperature whilst decreasing pH and oxygen levels. Moreover, climate change is increasing the occurrence and intensity of extreme events causing species extinction and range shifts, which can also have economic impacts. Along with overfishing and deoxygenation at local scales, algal pathogens and parasites can substantially increase with ocean warming. Warming, together with elevated pCO₂, thought to enhance the frequency, magnitude and duration of harmful algal blooms in coastal marine and freshwater ecosystems. In this session we invite contributions from marine and freshwater biologists and ecologists to bring diverse expertise and new perspectives to the impact of climate change on algae. We encourage submissions from laboratory, field, and mesocosm studies that offer new insights into the functioning of benthic and pelagic ecosystems at the genetic, population, community and ecosystem scale under biotic and abiotic stressors. Multi-stressor studies on ecosystem function are encouraged as well as papers that offer insights into potential for adaptation and resilience.

4. The Use of Algae as Biomonitors in Freshwater and Marine Systems

Convenors: Professors Martin Wilkinson and Juliet Brodie

Algae have been used as pollution indicators for a long time but EC Directives of the last two decades have broadened their use to ecological and environmental quality assessment of habitats. These Directives include Water Framework Directive (WFD) and Marine Strategy Framework Directive (MSFD) and utilise both planktonic and benthic forms, marine and freshwater. A challenge in developing suitable tools has been the lack of algal taxonomic education in recent years leading to attempts to simplify assessments. Recent molecular advances suggest that in some eDNA may be used as an aid to simplify survey work. Algae have also been used in the linking of ecological status to nutrient criteria. Climate change can result in species distribution changes both as loss of species and introduction of alien species. We can use impending changes in species as indicators of potential ecosystem damage from loss of key species and introduction of harmful ones.

We invite submissions of papers on both marine and freshwater algae, microscopic and macroscopic, looking at recent indicator tool development but also papers looking to the future indicator uses of algae and to applicability of new molecular techniques.

BOOK OF ABSTRACTS

Oral abstracts

Manton Prize

Sensitivities of key freshwater species to environmentally relevant exposures of microcystin LR

Oloyede Adekolurejo, Chris Hassall; Paul Kay (University of Leeds)

The worldwide expansion of microcystin-producing cyanobacterial blooms and the release of toxic microcystins in water potentially threaten human health, aquatic biodiversity and ecosystem integrity in freshwater systems. It is however unknown how individual species across different trophic levels in the freshwater food web may respond to microcystin exposures during toxic blooms. To test the hypothesis that species will differ in their sensitivities to environmentally relevant concentrations of microcystins, we conducted a battery of 72-hour algal growth inhibition test on the phytoplankton species, *Scenedesmus quadricauda*, 48-hour acute toxicity test on the zooplankton grazer, *Daphnia magna*, and 96-hour acute toxicity on two species of amphipod shredders, *Gammarus pulex* (native spp), and *Dikerogammarus villosus* (invasive) using pure MC LR and crude cyanobacterial extract treatments. Relative the control, pure MC LR treatments strongly inhibited the growth of *S. quadricauda*, while the photosynthetic pigments were not affected by both pure MC LR and the crude extract treatments. Survival of *D. magna* neonates was significantly reduced by *Microcystis* extract. However, neither pure MC LR nor extract treatments affected the survival of both native and invasive amphipods. Our results suggest that the toxic effects of microcystin on freshwater organisms depend on the species involved and that microcystin alone is not likely to be primarily responsible for the observed negative effects on organism during toxic freshwater blooms.

Flabellia petiolata in England - cryptic long established species or recent colonist?

Lin Baldock, Pilar Díaz-Tapia & Christine Maggs (Dorset Seasearch)

With increasing concern about the impacts of climate change and the arrival of invasive non-native species there is a growing need for experienced observers to monitor the appearance of new taxa. However, the origin of the new “arrival” needs to be correctly determined. Recently the green alga *Flabellia petiolata* (Halimedaceae, Chlorophyta) was confirmed from sites on the Dorset and Hampshire coasts. Using *rbcl* and *tufA* sequences together with morphological studies we demonstrated that English samples were identical to available GenBank sequences for this species from the Mediterranean. This alga was at one time considered to be endemic to the Mediterranean but is also now recorded from the Cape Verde and Canary Islands as well as the southern Atlantic coast of Spain. In England *F. petiolata* was found in three sites, in the lower infralittoral and upper circalittoral growing directly on silty, calcareous bedrock (limestone or chalk) in areas with elevated current speeds and generally high turbidity, among sparse, short algal growth. The species was first noticed in its typical flabellate growth form, and subsequently blue-ish green filaments emerging from soft, light, silty sediment proved to be the same species. Photographic evidence shows that the species occurs commonly on these rock types as filaments, the flabellate part of the frond being buried. Filamentous green algae are generally considered to be “difficult” to identify and are often either overlooked or ignored in the field. The majority of the English records were collected while participating in the citizen science programme Seasearch with some additional data obtained during professional biological surveys. Possible reasons for the apparent disjunct distribution of *F. petiolata* will be explored, including its cryptogenic status: non-native introduction or relict distribution from a wider Holocene occurrence and subsequent colder periods in this epoch? Is this merely a cryptic species occurring subtidally as unremarkable green filaments buried in silt and overlooked to date in England? Might its appearance be due to recent climate change?

Limiting lifestyles – how plankton lifeforms are changing in UK marine waters

Mike Best, (Environment Agency)

Assessment tools developed under the Water framework Directive from 2007 onwards have enabled us to classify estuaries and coasts based on phytoplankton biomass (chlorophyll-a), taxa cell counts and seasonal succession of functional groups. However recent developments under the Marine Strategy Framework Directive and UK Marine Strategy by the UK Pelagic group has allowed us to look at our data in a different way. One of the key shifts has been the inclusion of the lifeforms concept and state space of pairs of ecologically relevant lifeforms. This allows some integration across organisations, methods and sea areas. Measurement of the shape of change in plankton communities provides new information on the state of our near- and offshore phytoplankton communities. Results suggest that the phytoplankton community may be changing in ways that correlate to changes in nutrients and nutrient ratios in inshore waters and possibly climate change further offshore. These impacts may ripple further up the food chain. These views provide a compelling case to review our current thinking in both coastal and marine waters.

Responses of phytoplankton to climate in the North Atlantic Ocean: past, present and future

Gregory Beaugrand, *Loick Kléparski, Guillaume Signoret, Mariarita Caracciolo (Université de Lille)*

Climate change is having a discernible influence on marine biological systems of the ocean. Among biological components of marine ecosystems, phytoplankton are especially important because they are at the basis of the oceanic food chain, they contribute to the biological carbon pump, and last but not the least they are very sensitive to climate-induced environmental alterations. We will review expected changes in phytoplankton from the species to the community level looking at processes such as phenology, annual phytoplankton succession and spatial distribution. We will try to identify biological processes at work and will propose a way to understand and anticipate the effect of climate change on phytoplankton using a unifying theory called the MacroEcological Theory on the Arrangement of Life (METAL).

A model system to improve our understanding of red algae – oomycete interaction

Janina Brakel, *Janina Brakel, Yacine Badis, Callum O'Connell, Pedro Murua, Dieter G. Müller, Gwang Hoon Kim, Claire M. M. Gachon (Scottish Association for Marine Science)*

Rhodophytes are frequently inhabited by intracellular holocarpic oomycete pathogens, such as of the genus *Olpidiopsis*. *Olpidiopsis porphyrae* and *Olpidiopsis pyropiae* are recognised as one a major threat to *Pyropia* farming in Asia, causing significant loss of seaweed production each year. Screening large-scale metabarcoding datasets for sequences related to those of described red algae infecting *Olpidiopsis* species reveals a high diversity and a worldwide distribution of this genus ranging from tropical to the polar waters. However, despite the economic importance and global distribution our understanding of these pathogens and their interaction with its red algal host is in its infancy, as is our understanding of oomycete specific red algal defence mechanisms. Here, we present a pathosystem to study these basal oomycetes and its interaction with the red algal host. We isolated eight *Olpidiopsis* sp. strains from *Porphyra* sp. and marine 'Bangia' sp. in Western European waters. These are maintained in co-culture with clonal marine *Bangia* isolates of the clade 'Bangia 02' and 'Bangia 03' (nomenclature according Sutherland et al 2011). In this talk, we will present an ongoing study that combines RNAseq and microscopy (fluorescence and transmission electron microscopy) with the aim to generate a comprehensive molecular and morphological dataset to explore the host – pathogen interaction. Ultimately, we hope that this model system will provide new opportunities to enquire about virulence and defence mechanisms in oomycete – red algae interaction which will be of relevance to support a sustainable red algal cultivation.

Towards understanding the prokaryote microbiome composition and impact on carrageenophyte red algae

Juliet Brodie, Georgia Ward, Stuart Ross, Grant Stentiford, David Bass (Natural History Museum, London, UK)

Seaweeds are known to coexist with an associated community of prokaryotic and eukaryotic co-localised and co-evolving taxa, including bacteria, protists, fungi and other algae. This holobiont is increasingly recognised as influencing host health status, particularly bacteria which can be beneficial, modifying the host's interaction with grazers, epiphytes and abiotic factors. Other members can be pests (endobionts and epibionts, including other seaweeds) and pathogens (bacteria and micro-eukaryotes). Little is known about the interactions between these taxa and how they are influenced by environmental conditions and host, or how the composition of these communities vary over time, holobiont health status and host life-stage. Global seaweed aquaculture is a rapidly expanding industry, with the majority of production based in Asia (including countries such as China, Indonesia, the Philippines and the Republic of Korea). Eucaumatoid red algae (*Kappaphycus* and *Eucauma* spp.) are of particular importance as they are commercially exploited as a source of carrageenan, a polysaccharide used for thickening foods and in other industrial processes, e.g. cosmetic and pharmaceutical production. However, the yield of these crops is limited by outbreaks of disease and pests, in particular outbreaks of epiphytic algae, and a diseased state known as 'ice-ice', which causes bleaching of the thallus. 'Ice-ice' is thought to be caused by opportunistic bacterial infection, though the identity of disease-causing taxa, and their interactions with abiotic factors, other holobiont components and the host remain unknown. Understanding these interactions is critical for minimising the impact of disease outbreaks on commercial seaweeds. *Chondrus crispus*, a traditional North Atlantic source of carrageenan, is a potential model by which to study carrageenophyte microbiome composition and variation. High-throughput 16S sequencing, paired with light microscopy, are being used to study composition of prokaryotic communities across seasons in individual host tissues of life stages of *C. crispus* collected in Dorset, UK.

Impact of increased ice-sheet melt on the phytoplankton community within Greenland's fjords

Amanda Burson, Suzanne McGowan (University of Nottingham)

Arctic fjords are a major site of interface between ice-sheet derived freshwater and ocean marine water. This study seeks to understand the to-date unstudied impacts of increasing GrIS melt-water on phytoplankton communities found in Arctic fjord systems. Phytoplankton are the base of the marine food web and play a determinant role in the overall productivity of the fjord system, including economically important fisheries. In the last 20 years, the Arctic has warmed twice as fast as the global average. As a result, Greenland ice-sheet (GrIS) melting currently exports over 400 km³ of freshwater annually and is expected to increase with further warming. In the summer of 2019, record breaking ice loss occurred with reciprocal increases in meltwater entering the fjord system. Two investigative surveys were conducted along the 160 km Kangerlussuaq fjord system in western Greenland. The first survey was conducted in July of 2018, when summer GrIS melt fell within normal ranges for recent decades. The second survey was conducted in August of 2019, after the exceptionally high summer meltwater period. By comparing community composition of the phytoplankton alongside auxiliary water parameters between these differing years we can begin to forecast how a future fjord system may look. Analysis of the impact of increased GrIS meltwater on the nutrient regime, including the relative stoichiometry of major dissolved inorganic nutrients, may also give an indication of future impacts on limitation to growth and nutritional value of future fjord phytoplankton.

Manton Prize

A UV-inducible sunscreen pigment found in the extracellular mucilage of aerophytic green algae (Conjugatophyceae)

Anna Busch, (*University of Cologne*)

Terrestrial algae face several stressors including periodic drought and high solar radiation, both of which can be harmful to living cells. Some of these algae synthesise and accumulate light-absorbing substances that shield the cells against harmful radiation (non-photosynthetic pigments). A number of eukaryotic algae deposit such pigments in vacuoles or the cytoplasm, while sunscreen pigments in the extracellular matrix are - until now - only known from prokaryotic algae (Cyanobacteria). In the moist uplands east of Cologne, Germany ('Bergisches Land') we observed mass developments of terrestrial algae belonging to the polyphyletic genus *Mesotaenium* (Conjugatophyceae). These algae formed extensive black crusts covering moss, tree bark and bare soil, and exhibited pigments in their extracellular mucilage. *Mesotaenium* species with a pigmented mucilage were only rarely documented in the past, lack genetic identity and the function of their extracellular pigment is still unclear. We sampled such algae from diverse terrestrial habitats in Western Germany and North America (Great Smoky Mountains, USA), established several axenic cultures, studied the cell morphology with light microscopy (including confocal laser scanning microscopy), and sequenced the *rbcl* gene for phylogenetic inferences. The isolated strains showed common morphological characters (e.g. cell shape, plastid morphology), but varied in size and on the genetic level. Due to distinct morphological and genetic differences to the type species of the genus *Mesotaenium* (*M. endlicherianum*), we plan to introduce a new genus for the studied strains. To test whether extracellular pigmentation can be induced under light stress, algal cells were exposed to fluorescent tube lamps emitting photosynthetically active radiation (PAR) and ultraviolet radiation (UV). Cells treated with UV-B secreted blue mucilage and established pigmented capsules. As determined by microspectrophotometry, the pigmented mucilage absorbed in the entire solar spectrum, with two broad absorption maxima at about 300 nm and 580 nm. Both the UV-induced production and the absorption spectrum of pigmented mucilage strongly suggest a sunscreen function. We conclude that the densely coloured mucilaginous capsules may protect the algal cells from harmful solar radiation in their natural habitat.

International Algal Culture Collections: essential services for 21st century phycology

Christine Campbell, Maike Lorenz, Cecilia Rad Menendez and Rachel Saxon, SAG, University of Goettingen, Germany (Scottish Association for Marine Science)

Algal culture collections have evolved greatly since the first were established around 60 years ago. From simple strain repositories they are now essential platforms for biotechnology and phycological research. In August 2019 representatives from around 40 algal culture collections around the world met in Zagreb, Croatia at a satellite meeting to the 7th European Phycological Congress and discussed shared methods, challenges, and opportunities. Specific topics covered were sustainability, funding, cryopreservation, seaweed bio-banking, novel maintenance methods, algae for education and algae as bio-digital repositories. Here we investigate the number and range of culture collections around the world: their specialisations and capabilities; services for biotechnology such as patent depositing, confidential deposits, provision of DNA, taxonomic identification, training in isolation and culture; platform for strain information including secondary metabolite production; gene and genome sequences and much more.

Climate change and diseases of seaweeds, microbiome manipulations and restorative aquaculture

Alexandra Campbell, Peter D Steinberg, Ezequiel M Marzinelli, Adriana Verges, Torsten Thomas, Sharon Longford, Suhelen Egan, Nicholas Paul (University of the Sunshine Coast)

Like most marine organisms, seaweeds persist in a 'microbial soup' with millions of microorganisms occurring planktonically in each millilitre of seawater and forming complex biofilms on all living surfaces, including seaweeds. These microbiomes and their seaweed hosts interact in many diverse and complex ways and we are now beginning to understand the very fundamental inter-dependence of marine holobionts. I have studied how environmental change influences seaweed-microbe interactions and what the consequences are for the host and the coastal ecosystems they underpin. I will present data on climate-mediated diseases from three of the dominant habitat-forming species from around Australia – the country with the highest seaweed diversity and endemism in the world - with a particular focus on interactions at the molecular and cellular levels. Because climate mediated diseases are often implicated in seaweed declines, I have also worked on a long-term seaweed restoration project, affectionately named 'Operation Crayweed', which I will briefly describe. My current projects on the Sunshine Coast, focus on 'restorative aquaculture' and aim to make the restoration of seaweeds and other organisms economically feasible on ecologically relevant scales (i.e. hundreds or thousands of kilometres), which is the scale at which seaweed forests are currently declining in Australia each decade.

Functional alpha- and beta-diversity of seaweeds across the rocky intertidal elevation gradient

Laura Cappelatti, Alizée R. L. Mauffrey, John N. Griffin (Swansea University)

How the functional diversity of marine foundation species responds to environmental stress gradients remains poorly understood. Here we tackle this question by revisiting the textbook case of seaweed community changes across the rocky intertidal stress gradient from low to high shore. We surveyed seaweed assemblages across shore heights at sites in south Wales (UK), and investigated multiple aspects of functional diversity at large (entire zones) and small (1 x 1m quadrat) scales. Seaweed species were positioned in a multidimensional functional space and clustered into emergent groups to investigate patterns of redundancy. Null models were used to ascertain whether observed measures of functional α - and β -diversity differed from expected given observed species richness across zones. The overall seaweed trait-space showed signs of 'over-redundancy' with an uneven distribution of species across emergent groups. Species loss with shore height eroded redundancy and led to a contraction of functional richness - the total functional space occupied - in line with null model expectations at large and small scales. Functional dispersion - a metric that indicates trait complementarity of dominant species - was greater-than-expected across all zones at the large scale and in the low zone at the small scale. These results show: 1) Seaweed functional structure is vulnerable to species loss as redundancy is concentrated within a few groups and depleted under environmental stress; 2) Seaweed communities higher on the shore have a smaller range of trait values and, potentially, contribute a smaller suite of ecosystem functions; 3) Trait complementarity of abundant species may be an important mechanism promoting species coexistence and functioning among marine foundation species such as seaweeds.

Optimization of recombinant antibody production in the diatom *Phaeodactylum tricorneratum*

Félix Ciceron, Michael J. Allen, Paul Rooks, Tracey A. Beacham (Plymouth Marine Laboratory)

Diatoms are one of the most prominent groups of phytoplankton in oceans, having diverse and peculiar metabolisms. Notably, it has been shown that the model specie *Phaeodactylum tricorneratum* is able to produce and secrete recombinant human monoclonal antibodies. Thus, it can now be considered as a new interesting platform for antibody production, since it is recognized as safe, cannot be contaminated by mammalian-type virus, and grows on inexpensive medium. However, its production yield is currently too low to be competitive. Until now, antibody genes have been inserted in *Phaeodactylum* using the biolistic (gene gun) methods. This technique limits the possibility of genetic circuit optimization since the DNA vectors breaks and inserts randomly in the genome. An alternative transformation method has been developed recently, using bacterial conjugation to deliver a self-replicating plasmid. This “soft” transformation allows maintaining the integrity of both the foreign genetic circuit, and the diatom’s original genome. This project consists in enhancing the yield and practicability of recombinant protein production in *P. tricorneratum*. It will rely on the optimization of the currently available replicative plasmid, combined with the establishment of a pilot scale process for the culture and purification. Various key DNA sequences will be tested independently and these bio bricks will then be combined in a final backbone vector. A major part of the project will be dedicated to scaling-up cultures from the classic 300 ml research laboratory volumes to pre industrial pilot scale (50 – 100L), and optimizing the downstream process of cell clarification, supernatant concentration, and protein purification. The product will be characterized in term of yield, affinity, and post-translational modification. This last attribute will be analyzed in collaboration with the University of Normandy. A previously produced anti-Hepatitis B antibody will be used as a reference, in order to compare with the results that were firstly obtained from biolistic transformation. By combining genetic and process optimization approaches, we aim to move from the current “proof of concept” stage, to a streamered line process that allows going from the cloning of a foreign gene to a pilot scale culture in less than three months.

Manton Prize

Novel fluorescence techniques to discriminate cyanobacteria in mixed phytoplanktonic assemblages

Emilie Courtecuisse, Stefan Simis, Kevin Oxborough, Peter Hunter, Gavin Tilstone, Evangelos Spyarakos (Plymouth Marine Laboratory)

Harmful Algal blooms (HABs) are increasing in frequency and magnitude, enhanced by anthropogenic activities, including climate change (Paerl and Huisman 2008). A number of bloom-forming species produce potent toxins and constitute an actual and future risk to human and animal health and ecosystem functioning. Many cyanobacteria species form HABs (CyanoHABs), mainly found in freshwater bodies (Cronberg et al. 2003). Rapid and precise methods are required to detect, quantify and gauge the physiological state of cyanobacteria in mixed freshwater phytoplanktonic communities. Fluorescence techniques provide accurate and rapid results without disturbing the environment, at relatively low cost. Cyanobacteria possess specific optical properties, exploitable, in theory, for their detection. In laboratory conditions, fluorescence measurements were carried out on individual cultures of a range of phytoplankton groups (chlorophytes, diatoms, and cyanobacteria) under different light conditions (intensity and colour). Mixed phytoplanktonic community fluorescence was numerically modelled from single culture measurements. From these detailed measurements we understand fluorescence patterns of cyanobacteria in mixed communities and we determine which optical characteristics and measurement protocols are exploitable in the detection of cyanobacteria using new in situ sensors. References: Cronberg, G, EJ Carpenter, and WW Carmichael. 2003. 'Taxonomy of Harmful Cyanobacteria'. Manual on Harmful Marine Microalgae. UNESCO Publishing, 523–62. Paerl, H. W., and J. Huisman. 2008. 'CLIMATE: Blooms Like It Hot'. Science 320 (5872): 57–58. <https://doi.org/10.1126/science.1155398>

Establishing environmentally and commercially sustainable techniques for farming seaweed

Carly Daniels, Ian Ashton, Ross Brown, Mike Allen (The University of Exeter)

Worldwide demand for seaweed is rapidly growing, as is the interest in its cultivation. Leading seaweed producing countries include China, Indonesia and the Philippines, though unsurprisingly, interest in its cultivation is fast emerging across Europe. Nutrient-rich temperate waters and a large coastline make the UK, a prime location for seaweed cultivation. Through a collaborative research and development project, the University of Exeter (along with project partners the Cornish Seaweed Company) are investigating sustainable seaweed cultivation in Cornwall. The project aims to address three key elements of seaweed cultivation namely the practical how to, the environmental implications and the market potential of seaweed. This project will practically trial rope-grown cultivation of Sugar Kelp, *Saccharina latissima*, by integrating its culture into shellfish farming activities. Investigating practical seeding methods as part of a pilot scale farming operation the research program will also analyse the hydrodynamic loads on seaweed infrastructure, giving valuable evidence of the costs and practicalities of seaweed cultivation. In Situ environmental monitoring including observations of temperature, Dissolved Oxygen, Salinity, light, nutrients, chlorophyll, plankton community profiling and wave and current profiling will be used to assess the marine environment. This data will help to understand environmental drivers of production success through biomass monitoring and determine the environmental implications of seaweed cultivation. In particular, how seaweed may reduce harmful algal blooms (HABs), how it may enhance other aquaculture activities; and model and physical influences on the water body around the site. This project will also look into alternative uses for seaweed that can diversify market potential of the harvested product. Seaweed provides a versatile biomass that has diverse qualities, by investigating a selection of these qualities, including the lipid and carbohydrate concentration, we will start to uncover alternative market potential. This project presents one of a growing number of studies that looks to bring macroalgal culture to the South West of England and shows vast potential.

Manton Prize

Characterising the role of NADPH oxidase in marine diatoms

Jack Dickenson, Glen Wheeler, Mark Moore, Colin Brownlee (Marine Biological Association of the UK)

Introduction Tight control of cellular redox state is important for healthy cell homeostasis. Imbalance in the production or removal of reactive oxygen species (ROS) can cause oxidative stress damage to cells. However, controlled production of ROS can be harnessed by cells for signalling or other aspects of metabolism. NADPH oxidase (NOX) proteins function primarily to produce extracellular ROS, channelling intracellular electrons to react with extracellular oxygen. NOX derived ROS production has well-characterised roles in defence in mammalian cells. However, NOX proteins are diverse and widespread, being present in plants, algae, fungi and bacteria, and produce extracellular ROS for functions other than defence. Understanding of the roles of NOX proteins outside of mammalian and plant cells remains limited. We focused upon characterising roles of NOX proteins in marine diatoms. **Methods** We explored the involvement of NOX proteins in relation to photosynthesis regulation in the model diatom *Phaeodactylum tricornutum* using a range of techniques. These included molecular techniques such as genetic transformation. We explored the effect of chemical inhibition of NOX to cellular physiology through assays measuring extracellular ROS production and photosynthetic performance. **Results** *P. tricornutum* showed a clear link between increased extracellular ROS production and increased light intensity. Furthermore, chemical inhibition of diatom NOX proteins dramatically affects photosynthetic output, leading to changes in cellular redox status and compromised cellular physiology, particularly to photosynthetic machinery. **Discussion** We suggest diatom NOX proteins are crucial to healthy cellular physiology by acting to alleviate excess electron stress by removing excess reductant generated during photosynthesis to balance the redox state of NADPH. This adds to growing evidence showing how diatoms are capable of metabolic coupling to reduce electron pressure, helping explain diatoms remarkable tolerance to high light intensities.

Phytoplankton Assemblage in a Tropical Harbour: Microscopy Versus Chemotaxonomy

Owoyemi Elegbeleye, 1. Dr. Ikenna Charles ONYEMA (University of Lagos, Nigeria)

ABSTRACT INTRODUCTION: Investigations into phytoplankton community structures in Nigerian waters have always been carried out using conventional microscopy. Microscopic methods are not sufficient because very small-sized phytoplankton species are easily missed out from sample processing and examinations. At present, there is a dearth of literature on pigment-derived phytoplankton assemblage in Nigerian waters. The aim of this study was to assess the phytoplankton spectrum of the Lagos harbour using a combination of microscopic and chemotaxonomic methods. **METHODS:** Phytoplankton diversity and variations in water quality indices were investigated for twelve months from May 2015 to April 2016 following standard methods. Scanning electron microscopic (SEM) images of phytoplankton species were taken with a JEOL JSM 5310 using between 12 and 15 kV accelerating voltage. Chemotaxonomic assessment of phytoplankton was done using a C8 reverse-phase High Performance Liquid Chromatography (HPLC) pigment-labeling technique. **RESULTS:** All water quality parameters investigated, with the exception of reactive phosphorus, fell within Federal Ministry of Environment (FMEnv.) permissible limits. A total of 96 phytoplankton species belonging to five classes were recorded from microscopic observations. Bacillariophyceae (diatoms) comprised 72 species, Chlorophyceae (green algae) had 2 species, Cyanophyceae (blue-green algae) was represented by 11 species, Dictyochophyceae (silicoflagellates) had 1 species and Dinophyceae (dinoflagellates) comprised 10 species. The results from HPLC pigment-labeling technique validated microscopic observations for diatoms, dinoflagellates, blue-green and green algae. However, there were detections of coccolithophores and cryptophytes by HPLC which were not seen under the microscopes. From this study, *Achnanthes eureka*, *Hyalosynedra laevigata*, *Mastogloia cuneata*, *Mastogloia emarginata*, *Navicula formenterae* and *Palmerina hardmaniana* are new records of diatoms in Nigerian waters. **DISCUSSION:** Nutrient stoichiometry showed a clear nitrate limitation in the wet months which could be attributed to excessive supply of phosphorus from allochthonous and human-induced autochthonous inputs. The dominance of tycho planktonic taxa, which are tolerant to wide fluctuations in salinity and dissolved solids, suggests that the Lagos harbour is experiencing dramatic run-off from terrestrial systems. This study documented a pioneering effort at chemotaxonomic assessment in Nigeria, leading to identification and quantification of nineteen phytopigments. **Keywords:** Chemotaxonomy, Harbour, Microscopy, Phytopigments, Phytoplankton

Manton Prize

Contrasting temperature performance of two co-occurring digitate Arctic kelp species

Kiara Franke, Daniel Liesner, Inka Bartsch (Ifred-Wegener-Institute, Helmholtz Center for Polar and Marine Research)

Understanding the physiological responses of macroalgae to changing temperatures is crucial to predict future ecosystem changes under the threat of climate warming. The two phenotypically similar digitate kelp species, *Laminaria digitata* and *Hedophyllum nigripes*, inhabit overlapping ecological niches in the Arctic, but their southern distribution boundary is dissimilar. This suggests a different adaptation of their life cycle stages towards temperature. We investigated growth, upper temperature limit and photosynthetic characteristic of juvenile sporophytes, and upper temperature survival and gametogenesis of gametophytes of both kelp species along temperature gradients in a full-factorial approach. We thereby add further data for an Arctic *L. digitata* population and present the first ecophysiological investigation for *H. nigripes*, a species formerly partially confused with *L. digitata*. It became evident that both co-occurring species have a fundamentally different temperature performance in both life-cycle stages. Arctic *L. digitata* gametophytes survived 24°C and sporophytes survived 21-22°C, and thereby temperature tolerance was 4°C or 5°C higher than in *H. nigripes* gametophytes and sporophytes, respectively. Recruitment of juvenile sporophytes was similar for both species at 5 and 10°C. Whereas *H. nigripes* had an advantage over *L. digitata* at 0°C, *L. digitata* was the only species recruiting at 15°C. *H. nigripes* showed a much better sporophyte growth performance at 0 and 5°C than *L. digitata*, but photosynthetic parameters (rETR-irradiance curves) suggest that both populations are well adapted to Arctic temperatures. The overall temperature performance of *H. nigripes* shows a true affinity to Arctic to sub-Arctic temperatures, while Arctic *L. digitata* behaves similarly to temperate populations. Data suggest that future increase in Arctic seawater temperatures may hamper the success of *H. nigripes* and favour *L. digitata*. Whether both species take the same or different functional roles in Arctic kelp forest communities, however, remains unresolved.

Manton Prize

Under the ice: Microbial mats of Lake Untersee, Antarctica

Carla Greco, Marian Yallop, Gary Barker, Anne D Jungblut (Natural History Museum London and University of Bristol)

Cyanobacteria have shaped biogeochemical ecosystems on Earth since their evolution approximately 2.5 billion years ago and are particularly successful at surviving in extreme environments. Whilst the presence of cyanobacterial mats in the polar regions has been recorded historically, from nineteenth century exploration expeditions, the emergence of next generation sequencing techniques enables a more in-depth study of cyanobacterial diversity and community structure in perennially cold environments. Under low disturbance environments, cyanobacterial mats are able to form complex 3D structures that are laminated through seasonal growth and incorporation of sediment. A fascinating example of these structures comes from Lake Untersee, East Antarctica, where unique cone shaped structures and pinnacles have been reported. These structures are of particular geological interest as they are modern day analogues of Archean stromatolite fossils. It has been suggested that the microbial community can influence the morphology of the mats and understanding the ecology and the microbial interactions of modern mat formation may aid in interpreting the formation of Archean fossils. Analysis of 16S rRNA sequencing data demonstrated that the biofilm mats of Lake Untersee consist of diverse microbial communities. Consistent with other Antarctic freshwater ecosystems, Lake Untersee was dominated by cyanobacterial benthic mats that additionally included prevalent phyla including Proteobacteria, Verrucomicrobia, Planctomycetes and Actinobacteria. The cyanobacterial taxa were composed largely of *Tychonema*, but also included *Leptolynbya* and *Pseudanabaena* in all samples. These genera have been found in other Antarctic lakes, such as Lake Vanda, suggesting that these genera are ideal candidates for further research on the adaptation of cyanobacteria to cold environments.

A novel Ca²⁺ signalling pathway co-ordinates environmental phosphorus sensing and nitrogen metabolism in marine diatoms

Katherine Helliwell, Ellen Harrison, Joseph Christie-Oleza, Andrew Rees, Joshua Downe, Maria Aguilo-Ferretjans, Lisa Al-Moosawi, Colin Brownlee, Glen Wheeler (Marine Biological Association of the UK and University of Exeter)

Phosphorus is a critical nutrient controlling phytoplankton growth. Availability of this limiting factor can vary significantly in space and time, particularly in dynamic aquatic ecosystems. Diatoms are important eukaryotic phytoplankton that thrive in regions of pulsed phosphate supply, yet little is known of the sensory mechanisms enabling them to detect and rapidly respond to phosphorus availability. Here we show that phosphorus-starved diatoms utilise a novel Ca²⁺-dependent signalling pathway to sense and regulate cellular recovery following phosphorus resupply. This pathway, which has not previously been described in eukaryotes, is sensitive to sub-micromolar concentrations of phosphate, alongside a range of environmentally relevant phosphorus forms. Using comparative proteomics, we have characterised early adaptations governing diatom cellular recovery from phosphorus limitation. Strikingly, the dominant response was substantial enhancement of nitrogen assimilation proteins. This led to 12-fold increases in absolute nitrate uptake rates, relative to phosphorus-starved cells. Moreover, we find that the novel phosphorus-Ca²⁺ signalling pathway controls this primary recovery response. Our findings highlight that fundamental cross-talk between the essential nutrients phosphorus and nitrogen drive diatom recovery from phosphorus limitation. Moreover, a specific Ca²⁺-dependent phosphorus signalling pathway governs such ecological acclimation responses, and is thus likely critical to the success of diatoms in regions of episodic nutrient supply.

First insights into the molecular mechanisms involved in the perforation of algal cell walls by microbial 'protoplast feeders'

Sebastian Hess, (University of Cologne)

Trophic interactions of heterotrophic microbes with algae are diverse, and range from predation (or grazing) to highly specialised parasitism. This spectrum also contains so-called 'protoplast feeders', single-celled eukaryotes that perforate foreign cell walls to specifically consume the cell content of other eukaryotes by phagocytosis. With that, protoplast feeders are able to feed on microalgae with tough cell walls, which are otherwise hard to consume for other microscopic predators, and may play important roles in microbial food webs. Nowadays we know that there is a wealth of phylogenetically diverse protoplast feeders inhabiting marine, freshwater and soil ecosystems, e.g. the vampyrellid amoebae and viridiraptorid flagellates. However, the molecular mechanisms underpinning the intricate feeding behaviour of such life forms, especially the perforation of chemically diverse algal cell walls, are still unknown. In this talk, I will give an overview about known protoplast feeders from several evolutionary lineages and show how we study their interactions with microalgae. The viridiraptorid flagellates, in particular, are well-suited laboratory models to shed light on cell biological and biochemical processes taking place at the interface of attacking protoplast feeders and algal cell walls. Comparative transcriptomics of such flagellates in different life history stages and biochemical assays reveal the potential roles of carbohydrate-active enzymes (CAZymes) during prey cell recognition and cell wall dissolution. Some of the protein families found are well known from plant-microbe interactions and raise interesting evolutionary questions that will be experimentally addressed in future.

Drivers of biodiversity in phototrophic microbial mats and bacterioplankton in Antarctic freshwaters

Anne D. Jungblut, Josep Ramoneda, Ian Hawes (Natural History Museum)

Freshwater systems in continental Antarctica are particularly important hosts of inland biodiversity, with primary productivity and biomass generation relying on phototrophic microbial communities. To understand the implications of changing conditions on biodiversity and ecosystem function in these lakes and streams, it is important to investigate which environmental and ecological factors drive the local distribution and diversity of these microbial communities, as a prerequisite for predicting their responses to environmental change. Apart from adaptations to local abiotic conditions, a critical feature that determines the distribution of microbial taxa in time and space is connectivity, such as the physical continuity of the landscape that allows for the exchange of individuals across habitats. This connectivity may be particularly important where new habitat is being created through lake level rise, since the ability of organisms to colonise may play a role in community assembly. In this study, we sequenced the V4 region of the 16S rRNA gene to describe the spatial distribution of benthic cyanobacterial mat and planktonic bacterial communities across habitat units such as the proglacial Lake Brownworth, the Onyx River and the perennially ice-covered Lake Vanda in the McMurdo Wright Dry Valley, Antarctica. Our findings suggest strong compositional differences between the mat and water environments with Actinobacteria dominating water compared to Cyanobacteria and Proteobacteria, which dominated the mats. Differences between the composition of the mat and water environments were even stronger at the Cyanobacterial genus level (Figure 2B). Filamentous taxa such as *Phormidium*, *Tychonema* and *Leptolyngbya* dominated the microbial mats, whereas unicellular *Chamaesiphon* represented most of the Cyanobacterial taxa in water. Geographical differences in cyanobacteria and bacteria composition were also observed. However microbial mats and planktonic communities from the seasonally ice-free moat environments from different habitats tended to be more similar than communities from the deeper parts of Lake Vanda. There was also a correlation between community assembly and the history and stratification of the Lake Vanda. In summary, the study suggests that benthic phototrophic mat and planktonic communities are shaped by a combination of abiotic variables and different degrees of connectivity across habitat types in the Wright Valley, Antarctica.

Taxonomic study of Japanese Ecklonia and Eisenia (Laminariales, Phaeophyceae)

Hiroshi Kawai, Shingo Akita, Kazuki Hashimoto, Takeaki Hanyuda (Kobe University Research Center for Inland Seas)

In a multigene molecular phylogeny based on mitochondrial *cox1*, *cox3* genes and the *atp8*–*16S* rDNA region, as well as the plastid *atpB*, *psaA*, *psbA* and *rbcl* genes, *Ecklonia* spp. formed a monophyletic clade supported by high statistical values, and *Eisenia* spp. showed monophyly depending on analytical methods. The Japanese *Eisenia* species that used to be identified as *Eisenia arborea* (*E. arborea* sensu Arasaki) was shown to be genetically distant from *E. arborea* from the NE Pacific and *E. bicyclis* from Japan. *Eisenia* spp. were morphologically distinct in having a split meristematic zone in the mature thallus forming a dorsi-ventral blade with false branches. Therefore, we propose reinstatement of *Eisenia* as an independent genus and describe a new species, *Eisenia nipponica* from Japan. *E. nipponica* is distributed on the Pacific Coast of central Honshu, having a separate geographical range from *E. bicyclis*. In the genus *Ecklonia* s.s. four species (morphospecies) *E. cava*, *E. kurome*, *E. radicata* and *E. stolonifera* have been distinguished in the northeastern Asia. However, due to their remarkable morphological plasticity and very close genetic relationships, their species boundary was not clear. Monophyly of *E. radicata* was supported by the molecular phylogeny using concatenated DNA sequences of mitochondrial *atp8*–*16S* rDNA and *cox3* genes, but the independence of other three morphospecies were not supported. Instead, they formed three genetic groups having separate distributional ranges along Japanese coast. In the analyses using microsatellite markers, occurrences of the genetic exchange were detected in the contact areas of their geographical distributions. Based on the results, taxonomic revision of *E. cava*/*E. kurome*/*E. stolonifera* is discussed.

Setting nutrient thresholds to achieve good ecological status in surface waters

Martyn Kelly, Geoff Phillips, Heliana Teixeira, Sandra Poikane, Fuensanata Salas (Bowburn Consultancy)

Member States of the European Union currently use a wide range of nutrient criteria to support good ecological status in surface waters. National thresholds are set using a number of approaches; however, those countries that used expert judgement had significantly higher thresholds than those that used data-driven approaches. In order to facilitate the development of robust thresholds, the European Commission supported research into appropriate statistical approaches to setting nutrient thresholds and a summary of that work will be presented in this talk. In brief, regression-based approaches are the preferred approach but the relationship between pressure and biological response is often too weak for this to yield thresholds that are robust enough to drive management actions. Where nutrients are one of a number of pressures influencing the biota, then conventional regression leads to underestimates of thresholds and, potentially, very stringent regulatory regimes. In such cases, quantile regression can be employed, but this yields non-precautionary targets. Significant uncertainty remains even after accounting for significant co-variables and, therefore, the process of setting nutrient thresholds cannot be divorced from the management regimes that will enforce these targets. More esoteric statistical approaches have also been advocated and whilst these might have applications, those concerned with the development of environmental standards which could potentially affect utility bills and the profitability of businesses also need to ensure that the reasoning behind a threshold is clear and can be communicated to non-technical audiences.

Manton Prize

Idiosyncratic responses to increased salinity stress in populations of *Fucus vesiculosus*

Alexandra Kinnby, Co-authors: *Per R Jonsson, Olga Ortega-Martinez, Mats Töpel, Henrik Pavia, Ricardo T Pereyra, Kerstin Johannesson (University of Gothenburg)*

Introduction: Climate change related effects threaten the persistence of species worldwide. Genetic differences among populations of the same species, however, might make the populations react differently to climate-induced stress. In order to understand the responses of a species to climate change we therefore need to analyze the contribution of differences in tolerance among populations that may be particularly pronounced in areas with steep environmental gradients. Methods: Here we use a common garden approach to test variation in tolerance to reduced salinity among populations of the marine foundation macroalga *Fucus vesiculosus*. We sampled 6 populations within 100 km at the entrance of the brackish water Baltic Sea (NE Atlantic) where a steep salinity gradient is established (from 10 to 18 practical salinity units, psu). We measured growth, maximum photochemical yield, and phlorotannin content in tissue of the same individuals exposed to both current and future conditions. Results: We found that populations responded very differently to stress under future local salinity, a 4 psu decrease in all populations, as projected for this region by the end of the century. Some maintained growth at the cost of reduced phlorotannin production. One other population was strongly negatively affected while a second population at similar salinity, maintained growth and phlorotannin production when salinity was decreased. Discussion: Position along the environmental gradient, connectivity and genetic affinity of the populations seemed to play an important role to explain the different abilities to tolerate the simulated salinity decrease.

Temperature sensing in diatoms: cold shock and Ca²⁺ signalling

Friedrich Kleiner, Katherine Helliwell, Glen Wheeler, Colin Brownlee (Marine Biological Association of the UK)

Introduction Diatoms are a diverse collection of photosynthetically active microalgae with exceptional ecological importance. Temperatures lower than the optimum for growth or even survival can easily occur in the oceans due to seasonal changes or in coastal areas due to the impact of riverine inputs or tidal flows. As diatoms exhibit a global distribution, a big variety in cold tolerance is to be expected and partially already observed. Yet, nothing is known about the specific signal perception and transduction pathways, changes in transcription and activity of cold-stress related proteins in diatoms. This talk aims to present findings regarding the first two aspects, namely how the model diatom *Phaeodactylum tricornutum* senses drops in temperature employing the most versatile intracellular signalling system: Calcium signalling.

Methods We examined the occurrence of Ca²⁺ signalling in response to cold-shock employing a *P. tricornutum* strain with a genetically encoded fluorescence based Ca²⁺ biosensor using microscopy. Putative underlying ion channels and signal transduction pathways will be briefly discussed in frames of in silico based screening. Simple growth experiments assessing the survival in cold conditions will be presented as well. Results *Phaeodactylum tricornutum* portrays an easily reproducible influx of Ca²⁺ ions into the cytosol which correlates with strength and duration of the cold stimulus. The purpose as well as underlying ion channels of this cold response remain unknown.

Discussion Ca²⁺ signalling is employed by bacteria as well as single- and multicelled eukaryotes for a broad range of stress responses – including cold shock. Here we present promising evidence that it is the case for Diatoms as well, though the exact mode of action and consequence for the cells are not completely understood yet.

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The effect of climate change on coastlines, a case study of *Corallina officinalis*

Regina Kolzenburg, Federica Ragazzola (*University of Portsmouth*)

With increasing severity of climatic implications on, for instance, socio-economy, health and ecosystems due to anthropogenically induced global climate change, the necessity to research the complex interactions and impacts of these changes on organisms is urgent. At present, the impacts of climatic changes on marine coastal ecosystems are poorly understood. As critical components of global marine shallow water ecosystems, habitat builders and indicator species for climatic impacts, coralline algae are alarmingly effected. The species focussed on in this study and representing the majority of traits of coralline algae, is *Corallina officinalis*. We aimed at a laboratory experimental approach to assess the impacts of climate change across the species distribution in the NE Atlantic ranging from the northern boundary in Iceland to the southern boundary in Spain. Physiological and structural measurements were performed to determine thermal and chemistry-induced stress responses. These were compared between origins of populations and a distinct vulnerability of the southern marginal populations to increasing temperatures and changing carbonate chemistry were identified. Physiological rates such as respiration, primary production and calcification changed negatively in both southern populations indicating a great amount of stress, but showed an increase in central and northern populations. Structural parameters such as cell wall thickness or linear growth were greatest in northern populations. Central and southern populations, however, showed a reduction in both under climate change conditions leading to increased fragility. In addition to compromised resilience in southern marginal populations, northern marginal populations showed a great resilience and adaptation potential to future oceanic conditions. Based on these findings, the generally assumed Centre-to-Margin hypothesis regarding abundance as well as adaptation and resilience potential is not observed in *C. officinalis* and is suggested to be modified into a North-to-South gradient for this species. Overall, this study demonstrates that coralline algae (Rhodophyta, Corallinaceae) are vulnerable to ocean warming and ocean acidification. However, predicting the extent of their susceptibility to these changes is complex as it must be considered together with additional environmental and ecological factors. This study highlights the importance of ecological interactions in determining species responses to environmental change.

Utilization of municipal wastewater and flue gas for cultivation of microalgae for biofuel production

Sandra Lage, Francesco Gentili (Stockholm University)

Society faces major challenges in the production of sufficient amounts of biomass for energy and material production. Biomass from microalgae that are rich in oil has great potential as a complement to biomass from forests and agriculture. The success of microalgae as feedstock depends on achieving high yield with minimum energy input. The coupling of microalgae for phyco-remediation of wastewater, CO₂ recycling and biomass production for sustainable biofuels production is a feasible option. This study investigates the effect of algal species composition variability between ponds and through the season on the biomass biochemical composition and nutrient removal on municipal wastewater supplemented with flue gases containing circa 10% of CO₂. The local microalgae consortium was cultured during the 2017 summer season in open raceway ponds, with a surface area of 19.14 m², outdoors and inside a greenhouse in Umeå, northern Sweden. The results from the ponds suggest that the microalgae consortium can simultaneously remove dissolved nitrogen and phosphorus to low levels and sequester CO₂ independently of the dominant green-algae species, while generating a feedstock potentially useful for biofuels production.

Life cycle phase specific responses of *Coccolithus braarudii* to light intensity and nutrient limitation

Gerald Langer, Yun Wen Jie, Dorothee Kottmeier, Serena Flori, Alison Taylor, Colin Brownlee, Glen Wheeler (MBA)

Coccolithophores feature a haplo-diplontic life cycle comprised of diploid cells producing heterococcoliths and haploid cells producing morphologically different holococcoliths. In the field hetero- as well as holococcolithophore communities are present. These communities have distinct distributions in space and time. While heterococcolithophores tend to prefer winter and greater depths in the water column, holococcolithophores are often relatively dominant in summer and higher up in the water column. These distribution patterns strongly suggest that both life cycle stages occupy their own ecological niches, with the holococcolithophore being more tolerant to high light and temperature and low nutrient concentrations. In order to understand coccolithophore ecology and evolution it is necessary to understand the differential eco-physiology of hetero- and holococcolithophores. Culture experiments are an indispensable means to this end. In this study we performed two sets of culture experiments using the prolific coccolithophore *Coccolithus braarudii*. In the first experiment we compared haploid and diploid *C. braarudii* with respect to their responses to light intensity changes. We found the holococcolithophore to be more high light tolerant than the heterococcolithophore. We observed for the first time light stress induced malformations in coccolith crystal morphology. These malformations, however, were confined to the heterococcolithophore. In the second experiment we subjected a haploid and a diploid strain of *C. braarudii* separately to nitrogen and phosphorus limitation and analysed, inter alia, crystal morphology and growth rate. We conclude that the holococcolithophore copes better with phosphorus limitation than the heterococcolithophore. Responses to nitrogen limitation were life cycle stage specific too, but not with respect to all analysed parameters. Notably coccolith crystal morphology was affected in the heterococcolithophore only (both N- and P-limitation). Normally developed coccolith crystals are essential for coccosphere architecture. Given that the coccosphere is instrumental in the ecological success of coccolithophores and that the holococcosphere is insensitive to environmental stressors that severely affect the heterococcosphere, one significant advantage of the holococcolithophore life cycle stage could be its insensitive morphogenesis. This novel aspect of coccolithophore biology opens up a new perspective on coccolithophore eco-physiology.

Evidence supporting the 'healthy herd hypothesis' in a marine protist-diatom interaction

Davis Laundon, Nathan Christmas, Glen Wheeler, Michael Cunliffe (The Marine Biological Association)

Protist-protist interactions are ubiquitous, yet poorly understood, ecological processes that regulate the structure and function of microbial communities. Of these interactions, parasitism of marine diatoms has major implications on global biogeochemical cycling due to their essential role as primary producers. Environmental DNA sequencing studies have indicated that such interactions are widespread across the global oceans, however, our understanding of the underpinning physiology of protist-diatom parasitism is limited because of the relatively few cultured examples of these systems. Culture-based experiments are therefore vital in gaining a comprehensive understanding of trophic ecology and the impact on biogeochemical cycles in marine systems. Here, we present the isolation, stable co-culture and characterisation of a widespread thraustochytrid symbiont (herein designated 'ThrauL4') of the ecologically important diatom *Chaetoceros*, including the development of an experimentally tractable model system. Our physiological experiments characterise the ThrauL4-*Chaetoceros* interaction cycle and show that ThrauL4 preferentially targets senescent and 'unhealthy' diatom cells in a manner indicative of a necrotrophic parasite. We show that the selective targeting of 'unhealthy' diatoms manipulates the overall diatom population to be healthier, revealing the complexities of protist parasitism on marine phytoplankton communities. This study provides support for the 'healthy herd hypothesis' in a protist-protist symbiosis, a phenomenon typically associated with animal predators and their prey, highlighting the unanticipated ecological complexity that can be revealed from culture-based experimentation in protist-protist interactions. Taken together, our isolation of a stable thraustochytrid-diatom symbiosis is an important step forward in characterising the complexity of marine microbe-microbe interactions and sheds light on the ecophysiological and biogeochemical implications of phytoplankton parasitism.

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Local differentiation in heat response of *Laminaria digitata* at the range edges

Daniel Liesner, Louise Fouqueau, Myriam Valero, Michael Roleda, Gareth Pearson, Kai Bischof, Klaus Valentin, Inka Bartsch (Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research)

In recent years, kelp populations worldwide have faced decline and extirpation at their equatorward limits, while models predict a poleward shift of kelp ecosystems during climate change. To gain an understanding of local thermal adaptation and response plasticity in a forest-forming kelp species, we assessed populations of *Laminaria digitata* along its entire European distribution range for their capacity to withstand high temperature stress, and analysed population structure and diversity with microsatellite markers (n=12). We sampled wild meristematic *L. digitata* material (n=30) at six locations ranging from Kongsfjorden, Spitsbergen, to the southernmost distribution limit in Quiberon, France. In a heatwave experiment, we subjected samples from all locations to the same, sublethal temperature treatments (15–23°C for eight days including acclimation) and assessed growth, storage compounds, photosynthetic efficiency and pigment contents as response traits. Recovery was assessed following seven days at 15°C. Microsatellite genotyping revealed all sampled populations to be genetically distinct entities, underlying strong regional structuring between southern and northern clades. Genetic diversity was highest at the southern distribution limit in Quiberon and lowest in the geographically isolated population on the island of Helgoland in the North Sea. The physiological response of *L. digitata* to temperature was similar over the entire distribution range and did not reflect the mean temperature gradient along the latitudinal gradient. However, material from Spitsbergen and Helgoland presented subtle differentiations in their temperature responses, which reflect long-term local temperature histories at these sites. Finally, a heatwave reaching 23°C for five days led to a cessation of growth, from which none of the sampled populations recovered. Our results suggest that the heat stress response of *L. digitata* is generally stable across its distribution range, despite strong genetic structuring of the populations. Slight local differentiation occurred in populations from the most distinct thermal environments, but 23°C posed a growth limit for all populations. This implies that local adaptation in trailing edge populations of *L. digitata* might not alleviate detrimental effects of global warming.

Challenges and Opportunities in Developing a Sustainable Algal Biorefinery

Donal Mc Gee, Authors: Dean Johnson, Yueming Wang, Peter Koronaios, Avtar Matharu, Frederik Zitzmann, John Dodd, John Macdonald, Yat-Keung Lee (AlgaeCytes Ltd.)

Algae biotechnology offers an opportunity to deal with the concerns facing society's rapidly expanding populations in terms of health, food, and energy security. Algal biomass represents a sustainable resource of high-value bioactives including for example Omega-3 poly-unsaturated fatty acids (PUFAs), carotenoids, polysaccharides and proteins. These are of commercial interest for a wide range of industries including healthcare, personal care, sport health formulators and nutritional therapeutics. AlgaeCytes Ltd is a UK SME that is currently operating a commercial 12,000L pilot scale facilities at Discovery Park in Kent to manufacture Omega-3 PUFAs and other high-value metabolites from microalgae. AlgaeCytes is currently evaluating potential industrial-scale production sites with the aim of achieving a circular economic business model by developing a sustainable zero-waste biorefinery process. The biorefining and chemical valorisation of algal biomass presents an opportunity to maximise the full potential through the commercialisation of a range of high-value metabolites, in addition to value-added co-products from the spent biomass. Although algal biomass offers numerous opportunities for developing a sustainable multi-product biorefinery, multiple challenges exist in purifying the high-value metabolite of interest. These include for example, the partitioning the non-active components during bioactivity screening and removal of chlorophyll from the algal Omega-3 enriched oil. AlgaeCytes has undertaken extensive research to establish the most innovative and sustainable downstream processes for the extraction and purification of eicosapentaenoic acid (EPA) (20:5, n-3) from microalgae. These green extraction processes include "algal milking" using non-ionic liquids, super critical CO₂ PUFA extraction and EPA purification using counter current chromatography (CCC) or molecular distillation. Each process contains its own inherent challenges in successful extraction and purification using these technologies. Recent collaboration with the University of York, Green Chemistry Centre of Excellence (GCCE), has led to the successful characterisation of the polar and non-polar constituents of AlgaeCytes microalgal strain providing the key process performance indicators for the extraction and purification of EPA, proteins and value-added co-products (biopolymers, biochar, biofuels) from algal biomass. Developing a biorefinery employing multiple algal species could lead to new commercial opportunities for the co-formulation of multiple bioactives with applications in the healthcare, sports recovery biotherapeutic markets.

Reanalysis of the Theriot et al. (2015) 7 Gene Data Set Using Multiple Outgroups

Linda Medlin, Yves Desdevis (MBA)

A previous study of available diatom sequences tested the value of multiple outgroups in analyses of the 18S rRNA gene in recovering the three diatom Classes (Coscinodiscophyceae, Mediophyceae, Bacillariophyceae) as monophyletic groups (Medlin 2014). When certain outgroups were used (haptophytes ciliates, prasinophytes and chlorophytes), these classes were recovered with strong bootstrap support as monophyletic clades. This analysis used the variable V4 region of the 18S rRNA gene. In the phylogenetic analysis performed by Theriot et al. (2015), an additional 6 plastid genes were added to the dataset and this dataset was used with only one outgroup, *Bolidomonas*, and did not include all of the V4 region of the 18S RNA gene or bases beyond position 1200. Their analyses recovered a grade of clades from the so-called radial centrics into polar centrics, into araphid pennates, which themselves grade into the monophyletic raphid pennates. Theriot et al. have termed this grade of clades the structural gradation hypothesis (SGH) in contrast to the CMB hypothesis (Coscinodiscophyceae, Mediophyceae, Bacillariophyceae) of Medlin and Kaczmarska (2004). The analysis performed in this study took the 7 gene data from Theriot et al. and extracted only those species with a full complement of genes and added multiple outgroups and the entire 18S RNA gene including the V4 region. Analyses were performed by sequentially adding more outgroups using 1) evolutionary models with parameters relaxed across genes and codon positions for coding sequences (codon partition scheme = CP) and 2) without any partitions or evolutionary models (NCP). The CP analysis recovered a monophyletic mediophycean and bacillariophycean clade and three coscinodiscophycean clades: sequentially adding more outgroups did not change the topology of the clades but dramatically increased bootstrap support. NCP analyses recovered a monophyletic Coscinodiscophyceae and Bacillariophyceae and a Mediophyceae with 3 clades, each with strong bootstrap support. Finally to perform a total evidence analysis, morphological data was added to the molecular data set and weighted so that the few morphological data, which are logically coded by more than seven genes, could contribute equally to the data set as one of the seven genes. This addition produced a monophyletic Coscinodiscophyceae but the Bacillariophyceae was imbedded in the Mediophyceae in the CP analysis but not in the NCP analysis.

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Sr in coccoliths of *S.apsteinii*: partitioning behavior and role in coccolith morphogenesis

Erin Meyer, Gerald Langer, Glen Wheeler, Colin Brownlee, and Alison Taylor (University of North Carolina Wilmington)

Coccolithophores are important contributors to global calcium carbonate through their species-specific production of calcite coccoliths. Nannofossil coccolith calcite remains an important tool for paleoreconstructions through geochemical analysis of isotopic and trace element incorporation, including Sr, which is a potential indicator of past surface ocean temperature and productivity. *Scyphosphaera apsteinii* (Zygodiscales) exhibits an unusually high Sr/Ca ratio and correspondingly high partitioning coefficient (DSr) in their two morphologically distinct types of coccoliths. Whether or not this reflects mechanistic differences in calcification compared to other coccolithophores is unknown. We therefore examined the possible role of Sr in *S. apsteinii* calcification by growing cells in deplete, ambient, and higher than ambient Sr conditions (between 0.33 - 140 mmol/mol Sr/Ca). The effects on growth, quantum efficiency of photosystem II (Fv/Fm), coccolith morphology, and calcite DSr were evaluated. Reducing the Sr/Ca from ambient (9 mmol/mol) did not significantly alter the frequency of malformed and aberrant muraliths and lopadoliths, but at higher than ambient Sr/Ca conditions coccolith morphology was significantly disrupted. This implies that Sr is not a critical determining factor in normal coccolith calcite morphology in this dimorphic species. Interestingly, muraliths had significantly lower Sr/Ca than lopadoliths at ambient and elevated [Sr], and lopadolith tips had lower Sr than bases in ambient conditions. In summary, the Sr fractionation behavior of *S. apsteinii* is unusual because of an overall high DSr, and an inter- and intra-coccolith variability in Sr/Ca. We hypothesize that differential Sr- and Ca-binding capacity of coccolith associated polysaccharides may account for the unusual Sr fractionation of this species which can explain all observations made in this study.

Wavelength-dependency of photosynthesis on coastal seas: insights for chromatic light climate change

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Epicontinental temperate ecosystems are highly impacted by hydrodynamics and continental outputs which induce important quantity and quality light variations. In a climate change context, the decrease of water clarity due to turbidity increase by suspended particulate material (SPM) and colored organic materials (CDOM) at different scales of time and space, could have significant consequences on phytoplankton photosynthesis. Prior studies of microalgae photosynthesis have been based on blue light absorption capacity only. However, taking into account variations in pigment composition of cells in link with available chromatic light field and then subsequent photosynthesis activity is crucial. Here, we have realized some ex situ measurements of photosynthetic parameters spectral dependency for different light quality waters across the English Channel focusing on coastal, offshore and estuarine waters. We used for the first time at our knowledge a new generation fluorometer, the MultiColor-PAM (Schreiber 2012), on natural phytoplankton communities to produce high quality measures of light absorption capacity, the functional absorption cross section of PSII independently from the chlorophyll concentration ($\Sigma\lambda\text{PSII}$), at 5 different wavelengths. Results show first that $\Sigma\lambda\text{PSII}$ and relative photosynthetic parameters present strong spectral dependency consistent with photosynthesis assumptions. The clear $\Sigma\lambda\text{PSII}$ decreasing values from 440 to 625 nm is mainly controlled by light quality and biomass concentration variations. Secondly, absolute photosynthetic parameters (related to light absorption of PSII) still exhibit great variability with the spectrum and also between the samples which indicate high and reactive photoacclimation processes to changes in light environment. Variance partitioning analyses show that abiotic (as light quality and daily light dose) and biotic parameters (as phytoplankton community structure) controlled only 33.2 and 10 % respectively of photosynthetic parameters spectral variations. These results can be explained by changes in complex energy regulation processes in cells and highlight the great capacity and plasticity of natural phytoplankton communities for chromatic light utilization. Finally, our results suggest that natural phytoplankton communities could acclimate to changes in light quality of relative magnitude in relation to environmental changes.

The structure, function and threats to UK and Chilean kelp forests

Pippa Moore, Nathan King, Mathilde Bue, Albert Pessarrodona, Harry Teagle, Mike Burrows, Anna Yunnie, Tom Vance, Ally Evans, Alejandro Perez-Matus, Adam Gouraguine & Dan Smale, (Aberystwyth University)

Kelp forests extend along 25% of the global coastline, where they provide a 3-dimensional habitat that supports elevated levels of primary and secondary production as well as providing a range of goods and services to human society. At the same time these vital ecosystems are subjected to a range of anthropogenic stressors from direct exploitation to the impacts of climate change. Some of the early pioneering work on the ecology, distribution and standing stock of kelp was undertaken in the UK, but from the 1980s onwards attitudes and regulations towards scientific diving has meant that the UK has lagged behind other countries in our ecological understanding of kelp forests. Here I will present research undertaken over the last five years where we have undertaken large-scale (across 9° of latitude) mensurative experiments to better understand how the structure of kelp and kelp associated assemblages vary across natural gradients. Using space-for-time substitutions and experimental manipulations I will also outline the likely responses of kelp to future climate warming and what this might mean for the structure, functioning and ecosystem services kelp forests provide. Finally, I will outline research into the impact of commercial kelp harvesting on Chilean kelp forests and the drivers that may promote resilience.

Plankton Photosymbiosis

Fabrice Not, (*CNRS STation Biologique de Roscoff*)

Photosymbiosis is a symbiotic relationship between two or more organisms, one of which is capable of photosynthesis. Like other forms of symbiosis, photosymbioses can involve the full spectrum of trophic interactions from mutualism to parasitism. As in marine benthic environments (e.g. coral reef ecosystems), photosymbiotic associations are frequently encountered among plankton in marine pelagic environments and can involve various combinations of microalgae with bacteria, protists, or metazoans. After a brief overview of current knowledge on the diversity of the organisms involved in mutualistic pelagic photosymbioses, I will focus on Radiolaria (Rhizaria) a poorly studied yet significant plankton group in oceanic ecosystems. Evolutionary relationships based on single cell morpho-molecular approaches for main radiolarian groups and their microalgal symbionts emphasize the necessity to re-evaluate traditional classification structures. Those molecular phylogenies using universal taxonomic marker genes (e.g. 18S rDNA) also provide reference sequences that are critically required to appropriately annotate environmental meta-barcoding datasets and explore specific ecological patterns in relation to contextual parameters. In order to investigate further the functioning of photosymbiotic relationships between protists, I'll present a comparative genomic approach based on reference transcriptomes and dedicated bioinformatics tools such as similarity sequence networks. Identification of gene sets involved specifically in photosymbiosis will contribute to a better understanding of symbiotic relationships. Following this strategy we believe that genomic functional traits can be characterized and help decipher the distribution of targeted biological functions in the environment but also be valuable to conduct evolutionary studies.

Seagrass meadows – sensitive but mighty sentinels in a changing world

Irene Olivé, (University of Glasgow)

Seagrasses refer to the group of flowering plants readapted to live in seawater. Despite the relatively limited number of species belonging to this group, seagrasses colonize coastal areas all over the world playing a key ecological role in the functioning of coastal marine ecosystems. The high productivity and complex physical structure associated with seagrass meadows support high biodiversity and provide ecosystem services that rank among the highest on Earth. In the recent years a growing scientific effort has been devoted to understanding the functioning of these communities, particularly since large decreases in seagrass cover were reported globally a few decades ago. Seagrasses are considered globally threatened and early indicators of anthropogenic pressures. Nevertheless, recent studies highlight that seagrasses may play a key role in counterbalancing global climate change and creating refugee areas for associated sensitive species. The clonal nature of seagrasses makes them particularly suitable for studying how these organisms adjust to environmental gradients and cope with changes at different temporal scales, from short-term acclimation to long-term adaptation. The use of seagrasses as model species in climate change research not only contributes to our understanding of seagrass' biology and capacity to cope with climate change but may also shed light on the functioning of other marine macrophyte communities.

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Differential responses of *Stauroneis* sp. (Bacillariophyceae) exposed to varying conditions post-stationary phase.

Rachel Parkes, Lorraine Archer, Dónal McGee, Thomas Smyth, Eoin Gillespie, Nicolas Touzet (School of Science; Department of Environmental Science; Centre for Environmental Research, Sustainability and Innovation; Institute of Technology Sligo; Sligo; Ireland)

There has been an increasing drive to better valorise bio-based raw materials and products in the context of the sustainability of bio-based industries and the circular economy. Microalgae hold the ability to accumulate high-value metabolites which are sought after within industrial sectors such as bioenergy, pharmaceuticals, cosmetics or nutrition. Owing to their antioxidant, anti-inflammatory, antimicrobial or antiviral activities, the xanthophyll pigment fucoxanthin and polyunsaturated fatty acid omega-3 EPA have attracted increasing interests as they could be sustainably sourced from microalgae. A key challenge however resides in optimising the yields of these compounds within the microalgal biomass they are retrieved from. The marine diatom *Stauroneis* sp. LACW-24 was batch cultivated into its stationary phase of growth then subjected to varying regimes of light exposure (white, red, blue, green LEDs) and nutritional limitation (silica and nitrate) for 12 days prior to biomass harvest. Proximal analysis of the biochemical composition by ATR-FTIR showed that omitting nitrogen from the medium enhanced the proportions of carbohydrates. The highest EPA yields were obtained with the W-f/2, B-f/2, W-f/2(Si-1) and W-(f/2-1) sets (ranging from 3.8-4.6 mg g⁻¹). The fucoxanthin yield was the highest when cells were subjected to blue LEDs (6.2 mg.g⁻¹), a 2-fold increase compared to the controls. These results indicate that a two-stage approach to the cultivation of diatoms can be used for enhancing the production of the high-value metabolites fucoxanthin and EPA.

Bioenergy production from *Saccharina Latissima* through anaerobic digestion

Roshni Paul, Prof. Lynsey Melville, Dr. Sri Suhartini, and Dr. Michael Sulu (Birmingham City University)

This research aims to compare the feasibility of using wild and cultivated brown macroalgae species *Saccharina latissima* as a novel feedstock for co-digestion with agricultural crop waste residues including wheat residues, grass and maize silage, sugar beet-vegetable mix, pig manure and brewery spent grain. Anaerobic digestion of macroalgae has been an increasingly important area of research in recent years however co-digestion of macroalgae biomass with other traditional waste biomass is still a developing research area. Wild and cultivated *Saccharina latissima* samples were obtained from Northern Irish Coast, UK. Biochemical methane potential tests were carried out on the samples as a mono digestion and co-digestion feedstock. The results indicated that seaweed offered potential as a co-digestion feedstock enhancing the overall methane production. The co-digestion of wheat and *Saccharina latissima* had the highest specific methane production and pig manure showed the least specific methane production for both wild and cultivated biomass. This is possibly because seaweed has lower cellulose, no lignin and high carbohydrate content which aids better digestion performance. Comparisons were made in the biochemical properties of the wild and cultivated biomass indicating significant difference. The wild *Saccharina latissima* had a specific methane production of 0.249 l CH₄ Kg⁻¹VS and the cultivated biomass had a specific methane production of 0.393 l CH₄ Kg⁻¹VS. Results showed that cultivated biomass performed better than their wild counter parts. This is favourable for promoting utilisation of cultivated biomass than wild because it is unsustainable on a larger scale posing potential threats to the natural ecosystem. Macroalgae biomass cultivated in a marine environment also do not compete with agricultural land or potable water which makes it an attractive biofuel feedstock. However there are challenges involved for continuous AD operations including large scale cultivation and supply of seaweed, seasonal variability affecting the biochemical composition of the biomass, and thereby affecting the optimum carbon to nitrogen for co-digestion using macroalgae biomass.

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Global miniaturisation of temperate marine forests

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Accelerating anthropogenic changes to Earth's environment are favouring species with opportunistic life-history characteristics that are highly responsive to change. Existing work has documented how the dominance of opportunists transforms local habitat structure. Yet, the mismatch between local scales of observation and global patterns of environmental change has limited our capacity to understand these ecological changes, which operate across vastly different taxa and stressors. We examined the vegetation structure of marine forests that have experienced a shift towards dominance of opportunistic species during the past half-century, albeit as a result of different anthropogenic pressures. The present structure of those habitats differed across the globe, featuring varying heights, species diversity and being dominated by different algal groups. Importantly, differences among turf reefs dwarfed massively when compared to historical marine forest canopies, revealing a fundamental change in habitat architecture. Variation in the multivariate trait space of contemporary canopies has significantly reduced, converging towards short, small algal forms with numerous but smaller habitable spaces. This transformation has also resulted in a shift in the body size of fauna inhabiting the forests, suggesting that a community-wide miniaturization has occurred. We conclude that the ongoing declines in marine forests and replacement by algal turfs are a generalizable phenomenon occurring across temperate reefs, typified by a loss of habitat size, altered ecological function and a collapse of global seascape diversity.

Exploring the potential of Arctic coralline algae as a paleosalinity proxy

Lina Rasmusson, Jochen Halfar, Jason M. Hall-Spencer Hans W. Linderholm (University of Gothenburg)

As Arctic glaciers and ice sheets are melting rapidly, ocean salinity is declining. Salinity determines water density and strongly influences the strength and direction of currents and ocean circulation. It thus has great impacts on regional and global climate as it drives the transport of heat and energy. Establishing if salinity shifts are occurring naturally or if we are facing extreme events can help us predict the future impact of lowered salinity on climate patterns and ecosystems. As existing salinity reconstructions of Arctic waters are few, short and of low temporal resolution, new reliable salinity proxies are needed. For instance, the Intergovernmental Panel on Climate Change (IPCC) reported on the lack of such proxies in their report on the impacts of climate change on the oceans. A promising way to go for this purpose is Algeochemistry, the methodology examining how calcifying red algae, also referred to as coralline algae, are capturing environmental fluctuations within their annually banded structures. By analysing trace element- and isotopic composition in the growth layers of these algae, it might be possible to trace salinity variability hundreds of years back in time. *Clathromorphum compactum*, the species of interest in this project, has a geographic distribution throughout the high Arctic, where most other organisms suitable for marine climate reconstructions are absent. Algae have been collected around the coastlines of Svalbard and along a natural salinity gradient in a fjord system in Greenland. By determining the levels of the trace elements Ca, Mg, Ba, Mn, Li, Na and Sr using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICPMS) and the levels of $\delta^{18}\text{O}$ using mass spectrometry the signal changes in accordance to salinity will be investigated. All these elements have given slight indications, but not yet proven, salinity related responses in other organisms. Currently, *C. compactum* specimens are kept in a laboratory set-up consisting of aquaria with different salinities in order to detect the incorporation of the elements and $\delta^{18}\text{O}$ in controlled salinity settings. This project focuses on calibrating and evaluating the use of this method for making salinity reconstructions, aiming to validate the huge potential calcareous algae have as a historical salinity archive. The reconstructions will provide highly needed data and serve as a framework for future climate modelling, useful for researchers and policymakers when assessing salinity related effects of climate change in the marine environment.

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Hyperspectral mapping of *Ascophyllum nodosum* in western Ireland

Tom Rossiter, Tommy Furey, Tim McCarthy, Dagmar Stengel (National University of Ireland Galway)

The mapping of seaweed populations is important from both an ecological and economic perspective and the collection of baseline data will support informed management decision making. This research aimed to develop an integrated remote sensing approach for the assessment of the distribution and biomass of the intertidal brown furoid, *Ascophyllum nodosum* (Phaeophyceae). The high spatial and spectral resolution of drone-mounted hyperspectral sensors is potentially a useful tool for seaweed mapping, as many intertidal communities are spectrally similar and spatially heterogeneous. To develop this methodology, a site was chosen in Co. Galway where detailed drone-based remote sensing surveys were conducted. Hyperspectral surveys were conducted using a pushbroom sensor mounted on a DJI Matrice 600 Pro and supporting RGB surveys were conducted using a DJI Inspire 2. Surveys were conducted under stable light conditions and within a thirty-minute window either side of maximum low tide. Ground control points (GCPs) were collected, using a high precision RTK GPS, to georeference the data and a spectral radiometer was used to build a spectral library of canopy forming seaweeds and non-vegetated surfaces to support classification. High resolution RGB imagery allows for accurate digital delineation of selected cover classes, improving the efficiency and accuracy of both training and reference data collection. Two pixel-based classification approaches were used, Maximum Likelihood (MLC) and Spectral Angle Mapper (SAM). MLC classification results were significantly more accurate than SAM and showed higher levels of accuracy for the eight cover classes that we aimed to identify, including *A. nodosum*. Accurate data on total extent can now be gathered making this methodology useful for a range of intertidal resource assessment applications.

Salinity and time can alter epibacterial communities of an invasive seaweed

Mahasweta Saha, Robert M.W. Ferguson, Shawn Dove, Sven Künzel, Rafael Meichssner, Sven Neulinger, Finn Ole Petersen, Florian Weinberger (Plymouth Marine Laboratory)

The establishment of epibacterial communities is fundamental to seaweed health and fitness, in modulating ecological interactions and may also facilitate adaptation to new environments. Abiotic factors like salinity can determine bacterial abundance, growth and community composition. However, influence of the regional stressor i.e. salinity as a driver of epibacterial community composition (until species level) has not been investigated for seaweeds and especially under long time scales. We also do not know how abiotic stressors may influence the 'core' bacterial species of seaweeds. Following an initial (immediately after field collection) sampling of epibacterial community of an invasive red seaweed Agarophyton vermiculophyllum, we conducted a long term mesocosm experiment for 5 months, to examine the influence of three different salinities (low, medium and high) at two different time points (3 months after start of experiment and 5 months i.e. at the end of experiment) on the epibacterial community richness and composition of Agarophyton. Metagenomic sequencing showed that epibacterial communities changed significantly according to salinity and time points sampled. Epibacterial richness was significantly different between low and high salinities at both time points. Epibacterial richness also varied significantly between 3 months (after start of experiment) and 5 months (end of experiment) within low, medium and high salinity level. Irrespective of salinity levels and time points sampled 727 taxa consistently appeared in all Agarophyton samples hinting at the presence of core bacterial species on the surface of the alga. Our results indicate that both salinity and time can be major driving forces in structuring epibacterial communities of seaweeds with respect to richness and β -diversity. We highlight the necessity of conducting long term experiments allowing us to detect and understand epibacterial succession over time on seaweeds.

Kelp forests of Ireland: distribution, diversity, productivity and resilience to change.

Kathryn Schoenrock, Kenan M. Chan, Stacy A. Krueger-Hadfield, Jessica Adams, Aaron Golden, Tony O'Callaghan, Rory O'Callaghan, Julie B. Schram, Natalie Thompson, Aisha M. O'Connor, Jessica J. Ratcliff, Dagmar B. Stengel, and Anne Marie Power (National University of Ireland Galway)

Kelp forest monitoring along the west coast of Ireland has been on-going since winter 2017, shedding light on the diversity and productivity of these systems. The subtidal kelp forests dominated by *Laminaria hyperborea* host higher diversity than other nearshore habitats including maerl beds, *Serpula vermicularis* reefs, and tidal loughs across all seasons. Further, these forests produce up to 11 kg m⁻² biomass in shallower habitats during summer, and continually regenerate themselves after disturbances throughout the year, making them highly productive ecosystems. Unlike other kelp species worldwide, *L. hyperborea* is negatively buoyant and though it can be exported to adjacent habitats, such as maerl beds, the shore, and deep sea, dispersal is generally limited, especially for spores. Populations exhibit isolation by distance, and the highest genetic diversity (i.e., allelic richness, expected heterozygosity) lies in the populations along the south coast of Ireland (Co. Cork), a predicted glacial refugium. Current studies are exploring the eco-evolutionary aspects of resilience in *L. hyperborea* forests as well as monitoring tools which will help track distribution shifts in comparison to historical records.

Varicon Aqua: Making Algae Easy

Jacob Searle, Marco Lizzul (Varicon Aqua)

Varicon Aqua is the manufacturer of the Phyco™ range of photobioreactors and the Cell-Hi line of algal nutrients. Based in the UK our team has more than 30 years' of experience in design, consulting, construction and deployment of algae photobioreactors and aquaculture production systems worldwide. We provide both laboratory and industrial scale platforms for the cultivation of algae to a broad range of commercial and academic partners. A recent member of the team, Jacob Searle is a Plymouth University graduate with an MSc in aquaculture. Since starting at Varicon Aqua he has worked within the laboratory in an R&D capacity, been on active installations and has gained knowledge on photobioreactor operation. Furthermore, he has been instrumental within the innovation side of the business undertaking research on novel nutrient formulations, and CAD based photobioreactor design. As part of an increased focus on providing more cost-effective methods for algal growth, he has begun work on the "Eco" range of photobioreactors. A new product range that will allow for the cheaper cultivation of algae from lab to small-production scale. Benchmarking of the Cell-Hi range has also been undertaken, demonstrating the cost effectiveness of Cell-Hi products when compared to more conventional and expensive cultivation medium. This brief talk will give an overview on the current progress.

An accurate long-read genome and transcriptome of *Emiliana huxleyi*

Alastair Skeffington, Axel Fischer, André Scheffel (Max-Planck-Institut für molekulare Pflanzenphysiologie)

Algal genomes are providing ever greater understanding of the diversity of cellular and metabolic processes within the Eukarya, and have considerable potential for discoveries that could be harnessed in biotechnology. There is likely to be a great expansion in the genomic information available for algae with upcoming programmes such as the Darwin Tree of Life Project anticipated to generate thousands of new algal genomes. However the discovery of novel cellular functions within the genomes of these algae is dependent not only on the quality of the genomes, but also the quality of the gene models. De novo gene prediction algorithms often perform poorly on non-model organisms without good training data sets, and short-read sequencing data can only partially solve this issue because isoforms cannot be resolved, resulting in considerable uncertainty in the final protein sequences predicted. Thus long-read sequencing technologies, which can provide full length sequences of mRNAs, should be an essential part of modern genome annotation pipelines. We have used single molecule real time sequencing (SMRT, PacBio) to generate a new, high quality genome and transcriptome of a diploid, calcifying strain of the microalga *Emiliana huxleyi* (recently renamed *Gephyrocapsa huxleyi*). *E. huxleyi* is the most numerically abundant coccolithophore in the modern oceans, and modulates geochemical cycles through photosynthesis, production of calcified scales (coccoliths) and DMSP production. Although the original genome of *E. huxleyi* has driven much important research, it suffers from poor gene models and some genes are missing from the assembly. We show that our new genome and transcriptome is more complete than the original, and allows us to identify transcript isoforms and thus make an accurate predicted proteome. We describe a pipeline for achieving this analysis despite the complexities of working with a diploid organism with high heterozygosity. We validate our new gene models with proteomic data and show that we can identify proteins associated with calcification in *E. huxleyi* that were not part of the predicted proteome from the original genome. In addition, our new data allows an independent evaluation of the 'pan genome hypothesis' put forward by the original genome paper.

Climate-driven shifts in kelp forest structure: implications for productivity, biodiversity and resilience

Dan Smale, Albert Pessarrodona, Harry Teagle, Steve Hawkins, Pippa Moore (Marine Biological Association)

subpolar regions. As foundation species, kelps support high levels of primary and secondary productivity and provide habitat for diverse communities. However, the abundances and distributions of habitat-forming kelps are responding to global environmental change stressors, including ocean warming, extreme climatic events and the spread of non-native species. In the southwest UK, for example, the abundance of the 'warm' water kelp *Laminaria ochroleuca* has increased significantly in recent decades, as has the distribution of the invasive kelp *Undaria pinnatifida*. Conversely, the abundances of several northerly-distributed species (e.g. *Laminaria digitata* and *Alaria esculenta*) are expected to decrease under climate change scenarios. We examined the wider consequences of climate-driven range shifts and species replacements within kelp habitats, by documenting changes in primary productivity, trophic linkages, biodiversity and habitat stability. Results from several studies suggest that observed and predicted shifts in kelp forest structure may lead to impoverished assemblages in some reef habitats, altered timings and rates of primary productivity, shifts in trophic pathways and temporally less-stable habitats. Greater understanding of the (often subtle) community and ecosystem-level consequences of shifts/replacements of habitat-forming species is needed to better predict the wider impacts of ocean climate change.

Using historic samples to uncover Harmful Algal species niche preferences.

Rowena Stern, Vera Trainer, Stephanie Moore, Clare Marshall, Jessica Clarke, Martin Edwards (CPR survey, Marine Biological Association)

Harmful Algae are an increasing problem globally through toxin poisoning events to humans and marine life to deoxygenation and overgrowth. Despite many studies, their response to environmental drivers remain enigmatic. At the same time, prediction of harmful algae events is vital for food security, to mitigate against climate change effects and are a key monitoring target for Marine Strategy Framework Directive. Population sub structuring and a lack of species-level data for many harmful algae thwarts useful indicator development. The Continuous Plankton Recorder (CPR) Survey has sampled plankton over 6 million miles in the Atlantic since 1930, and a physical record exists from 1960s. Although preserved in formalin, a DNA-damaging agent, it is now possible to obtain techniques opening up long-term evaluation of harmful algae species at climate-change relevant scales. Here we discuss our findings on spatial partitioning of *Pseudo-nitzschia* and other key harmful algae species.

The Clones/Magheraveely Lakes - how water quality decline is reflected in charophyte lakes.

Nick Stewart, Yvonne McElarney, Frances Lucey, Joerg Arnscheidt, Sara Meehan, Darren Garland & Raymond Wilson (None)

The Clones/Magheraveely Lakes are a group of small kettle-hole marl lakes straddling the national border in Ireland. In the late 1980s all had extensive charophyte communities but this has declined due to nutrient enrichment in all of the lakes in the 30 years since. This study has shown a clear pattern of decline within the lakes which is influenced by the adjacent land management. This matches the patterns seen in similar declining sites elsewhere. The study also looked at how these changes are reflected in the standard lake monitoring methods and found them to be unsatisfactory.

Phagocytosis and the digestive vacuole of diploid calcifying coccolithophores

Alison Taylor, Elizabeth Stone, Madeline Liberti, Madison Cox, Emily Fox (University of North Carolina Wilmington)

Mixotrophy is widespread in unicellular marine algae with smaller size groups obtaining up to 25% of their biomass via bacterivory (Zubkov, M.V. et al. 2008 Nature 455, 224-248). Photosynthetic dinoflagellates in particular exhibit a variety of nutritional strategies, often combining phagotrophy with autotrophy. The heterotrophic and mixotrophic origins of the haptophytes are also well recognized, and genomic studies of haploid and diploid (calcifying) stages of coccolithophores suggest they possess the molecular machinery and capability to phagocytose and enzymatically degrade potential prey particles (Houdan, A., et al. 2006 Aquat. Microb. Ecol. 44, 291-301, Rokitta, S.D., et al. 2011 J. Phycol. 47, 829- 838). Using fluorescently labeled pH sensitive prey and confocal microscopy, we demonstrate phagocytosis and the development of a well-defined acidic digestive vacuole (DV) in the 2N non-motile calcifying stages of *Scyphosphaera apsteinii*. Experiments with fluorescently labeled particles revealed *S. apsteinii* ingested and accumulated beads up to 2 microns in diameter in the DV. This implies larger coccolithophores may not be limited to bacterivory, and could potentially consume larger picoeukaryote prey. We present evidence that the DV may be multifunctional in nature. Overall, our data supports mixotrophy through phagocytosis and degradation via a DV pathway in some calcifying heterococcolith-bearing coccolithophores. This has important implications for understanding nutritional strategies in these globally important marine protists.

Thin films of Life and the challenges of changing environments

Graham Underwood, *none (University of Essex)*

Have you ever slipped on a wet rock, or seen gold and green sheens on mud or sand? Then you have experienced an algal biofilm. Almost any wet surface will be covered with a mixed film of algae and other microbes, embedded in a matrix of slime. Biofilms are everywhere. They are exposed to extreme conditions: Damaging levels of light and ultra-violet radiation; temperature; wetting and desiccation; various pollutants. Despite this, the biological activity of biofilms is very high, and they make significant contributions to nutrient cycling and food chains in many freshwater and marine ecosystems. Drawing on examples from tropical, temperate and polar regions, Professor Underwood, President of the British Phycological Society, will show how our understanding of the chemistry, biology and ecology of diatoms, the major algal component of biofilms, has developed. The secrets of their success are due to high species diversity, metabolic, and behavioural flexibility. This provides the resilience for biofilms to face the challenges of their changing environments.

Limits of short and long term acclimation in the Arctic diatom *Melosira arctica*

Klaus Valentin, *Mirta Jacobs, Lin Jiang, Anique Stecher, Madlen Franze, and Erika Allhusen (Alfred Wegener Institute)*

Melosira arctica is currently perhaps the most productive diatom in the ice-covered Arctic Ocean and can contribute up to 80% to carbon export into the deep sea. However, we see a significant reduction in Arctic ice cover which will increase in the near future. A significant increase in SST is also expected until the end of the century. In our study we determined growth limits of *Melosira* in short- and long-term experiments of up to 15 months and found that this diatom is already fully adapted to polar conditions and life at sea ice. Temperatures of 8°C or higher light intensities are lethal after 2-3 months. Even more so *Melosira* shows adaptation to live inside sea ice as it contains in its nuclear genome two large gene families of anti freeze protein (AFP) genes typical of sea ice diatoms. One of the AFP families is novel for diatoms and has not been found in any eucaryotic genome. From our data we conclude that *Melosira arctica* will suffer from expected warming and reduction of sea ice cover which likely will decrease its primary productivity and carbon export contribution to the Arctic ocean.

Ecological stoichiometry of phytoplankton parasites

Dedmer Van de Waal, Kai Cheng, Thijs Frenken & Alena Gsell (Netherlands Institute of Ecology)

All life on Earth consists of a basic set of elements, notably including carbon (C), nitrogen (N), and phosphorus (P). Ecological Stoichiometry studies the balance of these elements, and as such provides a mechanistic framework based on first principles to understand ecological interactions. Generally, primary producers have flexible elemental demands and therefore a high stoichiometric plasticity, while consumers tend to have more strict nutritional demands and are stoichiometrically homeostatic. As a consequence, strong elemental imbalances at the base of the food-web may limit consumers and lead to trophic bottle-necks. The elemental demands as well as the extent of homeostasis is expected to be particularly high in parasites, such as viruses and fungi, as they lack complex cellular machinery. In a series of experiments, we tested how nutrient limitation of phytoplankton shifted infection dynamics of viruses and fungal parasites (chytrids) in harmful freshwater cyanobacteria. We showed that viruses are more strongly impacted by host P limitation, while parasitic fungi are more sensitive to N limitation. Thus, although an imbalanced nutrient supply will limit phytoplankton growth, it may more strongly limit their parasites, and as such ultimately provide the host with a stoichiometric refuge from diseases.

Oriented occlusions in Acantharia spicule growth

Jessica Walker, Vivian Merk, Paul J. Smeets, Derk Joester (Northwestern University)

Acantharia are single-celled protozoa that produce spicules of strontium sulfate that radiate out from the central cellular region. The spicule morphologies are highly intricate and species specific, thus under genetic control. The choice of strontium sulfate as a mineral substrate is highly unusual in nature, particularly as strontium is highly undersaturated compared to calcium in seawater. Currently, the mechanism by which they extract and concentrate strontium from seawater has not been determined, nor how the mineral growth takes place. We have examined the interior of the spicule to shed light on the involvement of biomacromolecules in the mineralization process. Utilising X-ray absorption spectroscopy (XANES) at the sulfur K-edge we were able to detect sulfated organic molecules present in the mineral phase. This was consistent with nanoscale low Z occlusions observed by STEM high-angle annular dark field (HAADF) imaging. Using this method, evidence of 'growth rings' radiating concentrically from the central region was observed, and the low-Z regions were shown to be most highly present in the centre of the spicule. These features are reflective of other biomineralizing systems including that of sea urchin embryonic spicules are suggestive of incremental outward growth. Overall, we present evidence for intracrystalline occlusions in Acantharian strontium sulfate spicules that may represent the present of biomacromolecules that are responsible for controlling crystal growth.

Exploring Eukaryotic Diversity Associated with Carrageenophyte Red Algae: A Study of *Chondrus crispus*

Georgia Ward, Additional authors: *Stuart Ross, David Bass, Grant Stentiford, Juliet Brodie (Natural History Museum)*

The red alga *Chondrus crispus*, known as Irish moss, is common along shorelines in Europe where it is a traditional source of carrageenan, a thickening agent used in foods, cosmetics and pharmaceuticals. Like all seaweeds, *C. crispus* exists with an associated community of bacteria, protists, fungi and other algae, with these organisms together comprising the holobiont. While the importance of the composition of this holobiont in influencing the development and health status of the host is becoming increasingly apparent, the majority of studies focus on the role of bacteria in modifying the host's interactions with grazers, epiphytes and abiotic factors. The identity of eukaryotic pathogens and symbionts and their interactions with their host remain largely unexplored. In this study we use 18S-targeted high-throughput sequencing, PCR screens targeted at known pathogen groups, and light microscopy to investigate the incidence and identity of eukaryotes associated with *C. crispus* tissues collected in Dorset, UK, and how this varies across seasons, individual host tissues and life history stages. We also discuss the importance of the methods used for understanding the role of the holobiont in influencing the health and disease of carrageenophyte algae.

Physiological responses of marine diatoms to osmotic stress

Glen Wheeler, Katherine Helliwell, Friedrich Kleiner, Serena Flori, Colin Brownlee (Marine Biological Association)

Diatoms are globally important phytoplankton that dominate many marine ecosystems. In order to thrive in these environments diatoms must be able to sense and respond to diverse environmental stimuli. Diatom communities, in particular those in estuarine and or sea-ice environments, may experience significant fluctuations in light, salinity and temperature over short time scales, necessitating cellular mechanisms that enable a rapid response. We have examined the signalling mechanisms that diatoms use to respond to these stimuli using the model diatom *Phaeodactylum tricornutum*. We find that a calcium-dependent signalling pathway is essential for survival of *P. tricornutum* in response to hypo-osmotic stress. Exposure to hypo-osmotic conditions results in cell swelling and triggers exhibit cytosolic calcium elevations that initiate in the apical regions and spread to the rest of the cell. This suggests that the stress is perceived locally in the apical region, but the propagating calcium wave enables a response at the whole cell level. We also find that distinct *P. tricornutum* morphotypes exhibit different osmotic-signalling sensitivities, suggesting that a pleomorphic lifestyle confers ecological resilience to osmotic stress in this species. Inhibition of calcium signalling by removal of external calcium results in excessive cell swelling and cell bursting in severe hypo-osmotic stress. The calcium-dependent signalling pathway is therefore essential for osmotic adjustment and likely contributes to the ecological success of diatoms in diverse environments that experience significant fluctuations in salinity.

Conservation challenges for a microscopic world: Documenting desmids

Joanna Wilbraham, n/a (Natural History Museum, London)

Freshwaters are amongst the most threatened habitats in the world. Many waters in the UK have irreversibly changed or disappeared and those that remain are under immense pressure largely due to habitat loss, pollution, recreation, abstraction and the introduction of non-native species. Climate change is also becoming a major concern for freshwater life. The conservation of biodiversity associated with freshwaters has for obvious reasons focused on the larger animal and plant species, however, microorganisms such as the algae play a fundamental role in these ecosystems and constitute rich assemblages which are also threatened. Desmids are a diverse group of freshwater microalgae which dominate the algal flora of nutrient poor, lentic waters and are particularly diverse in such oligotrophic habitats as moorland pools and shallow lakes. They are ecologically highly sensitive, acting as useful indicators of water quality. The conservation of microscopic organisms poses many difficulties due to taxonomic impediments and lack of knowledge of ecology and distribution. To gain a better understanding of desmid distribution patterns across the UK and Ireland this project has undertaken the digitisation of 50 years worth of biological recording data collated by desmid expert David Williamson. Reliable datasets of species occurrence are essential to biodiversity research and conservation so these data, in conjunction with published literature, will provide a basis for developing a more robust checklist of verified desmid taxa known to occur in the UK and Ireland and provide distribution information for these taxa. Furthermore, this will enable us to review the conservation status of the desmid flora and provide data of practical use in the designation and management of protected freshwater habitats.

Algal photophysiology drives darkening and melt of the Greenland Ice Sheet

Christopher Williamson, The Black and Bloom team (University of Bristol)

On the surfaces of glaciers and ice sheets, specialised species of 'glacier algae' belonging to the Zygnematophyceae are able to establish wide-spread algal blooms during summer melt seasons, with significant consequences for the physical (melt) and chemical (carbon and nutrient cycling) ice surface environment. To achieve this feat, glacier algae must balance their requirements for photosynthesis and growth with the exceptional stresses experienced, including extremes in temperature, desiccation, visible and UV radiation. Here, we report the first quantification of the photophysiological mechanisms that allow glacier algae to thrive on the bare ice surface. Significant secondary pigmentation is shown to enable tolerance of extreme irradiance whilst simultaneously repurposing captured UV and short-wave radiation for melt generation, with total cellular absorption increased ~50-fold by secondary pigmentation. In contrast, glacier algal chloroplasts positioned beneath shading pigments remain low light adapted and dependent on typical non-photochemical quenching mechanisms for photoregulation. On the Greenland Ice Sheet (GrIS) glacier algae direct only ~ 1% of incident energy to photochemistry versus 40 – 65% to ice surface melting, contributing an additional ~1.86 cm water equivalent surface melt per day in patches of high algal abundance (~10⁴ cells ml⁻¹). Our findings are critical for the incorporation of biological feedbacks into predictive models of GrIS surface mass balance and provide unique insight into how photoautotrophic life excels within icy environments.

Methods for monitoring habitat-forming seaweeds

Chris Yesson, (Zoological Society of London)

Habitat-forming species, such as kelp forests or coralline reefs, are important environmental indicators. Declines in these species will directly impact the habitats they create. Multiple anthropogenic stresses such as climate change, pollution and fishing are threatening a wide variety of marine species, which has led to a greater emphasis on monitoring for impact assessment and conservation planning. Although direct surveys remain the gold standard, they are time-consuming, expensive and often spatially limited. Using examples from our work, this talk will review methods of monitoring based on real-world examples such as: maximising the use of historical data, remote surveys from boat-based systems such as towed cameras and acoustic sensors, aerial imagery from drones and satellites, and even diversity monitoring using population genetics. There are many monitoring methods, each with their own benefits and disadvantages, and selecting the right method depends on many factors. Novel methods have the potential to widen our monitoring capacity and extend our knowledge of the distribution and abundance of macroalgae and other keystone marine species.

Poster abstracts

A microalga and its microbiome: Diversity, variability and not just a question of B12?

Georgina Andrews, (Algaecytes LTD)

Microalgae are a diverse group of phototrophic organisms, that have potential to produce a wide range of products important in creating a sustainable future. Microalgae have been seen to have associated bacterial populations and often grow poorly without this interaction. This may be due to many factors including the transfer of products such as cobalamin (B12), carbon sources and nitrogen sources. AlgaeCytes' proprietary microalgae ALG01 (Eustigmatophyceae), which produces Eicosapentaenoic acid (EPA), an important omega-3 oil, needed by many living things for growth and repair. ALG01 is grown phototrophically and with its associated microflora. The aim of this study was to investigate whether ALG01 could be grown axenically and to gain an insight into the role of the associated microflora. In the present study, axenic ALG01 had impaired growth, like many other documented axenic strains. The addition of B12, tryptone and glucose improved the growth of axenic cultures (approx. 50% increase) but did not return growth to normal levels when compared to non-axenic cultures. Eighty-three morphologically different bacteria were successfully isolated from an ALG01 culture through agar isolation. The strains were tested against the axenic ALG01 culture on agar where 65 showed a positive interaction, 18 showed no effect and none showed a detrimental effect. Addition to liquid cultures was not statistically significant when cultivated to early stationary phase of growth within a small-scale system. Ten strains with the most significant effect were sequenced and were identified as *Pseudomonas*, *Pimelobacter*, *Brevundimonas*, *Microbacterium*, *Comamonas* and *Sphingopyxis* spp. Genomic analysis of these strains showed them to have a plethora of possible products that may underpin any interaction with ALG01 i.e. B12 production and denitrification. The microbiome of ALG01 has been shown to be more significant than initially thought. More investigation is needed into the dynamics of all the species within ALG01 cultures and our study reflects that of other microbiome studies where there are complex interactions that are beneficial to growth, but their precise function is unknown. This has large implications in the industrial use of microalgae through culture management practices, increases in product production and an indicator of culture health and performance.

The effect of temperature on competition between *Laminaria* kelp species

Alissa Bass, (*The Marine Biological Association and University of Plymouth*)

Climate change driven increases in sea surface temperature are impacting marine species globally. In addition, the more frequent and intense extreme climatic events, such as marine heatwaves, are exacerbating the heat stress on these organisms. Temperature is a key driver of population structure and community composition, affecting abundances and distributions of species, as well as the interactions between one another. Here, we will investigate the effect of temperature on competition between kelp juveniles of three important *Laminaria* species found in the South West UK. Kelp are important foundation species of cold water and temperate habitats, supporting a high level of biodiversity, as well as having high economic value. Understanding how these species interactions shift with temperature will help us predict how they may change in the future and consequently how the structure and function of ecosystems may be impacted.

My Seaweed Looks Weird: the web portal to report diseased algae

Janina Brakel, *M. Strittmatter*, *M.M. Perrineau*, *P. Arce*, *J. Brakel*, *P. Murua*, *C.M.M. Gachon*
(*Scottish Association for Marine Science*)

Diseased algae have always been around, but finding one of them in the wild is mostly a chance encounter. Often, the eye of beach-walkers is drawn by seaweeds with an unusual aspect (deformed growth, discolouration, galls, holes or rot symptoms, etc.), but such encounters usually go unreported. “My seaweed looks weird”, as part of the GENIALG and GlobalSeaweedSTAR projects, is an online portal [1] where anyone can contribute weird-, or sad-looking seaweeds to accelerate research. We are encouraging scientists, seaweed professionals or members of the public to report and submit samples of potentially diseased algae. Using a combination of microscopy and potentially, DNA analysis, we shall endeavor to send back a diagnosis in-kind for all samples received. Our goal is to accelerate the description of algal diseases worldwide. We will use the data to identify and map diseases, as well as describe novel or emerging issues. With the marine environment undergoing very rapid changes worldwide, and in particular cultivation growing rapidly, the collected data will represent a baseline of what diseases occur where, both in the wild and in seaweed farms, in order to be able to detect and monitor any changes. With time, we will make the results of this work available through Open Access publications and a (yet-to-be-built) digital online atlas of algal diseases. We hope this tool will be a valuable source of information for seaweed farmers and researchers in the future.

Diatom-bacteria interactions: deciphering impacts on algal bloom regulation and toxicity

Laura Branscombe, Michael Cunliffe, Willie Wilson, Katherine Helliwell (Marine Biological Association)

Diatoms are widely distributed marine phytoplankton which contribute up to 40 % of marine primary productivity. These important marine algae can form large blooms which have large-scale impacts on global carbon cycles, and heavily influence phytoplankton ecology. Some bloom-forming diatoms can also release harmful toxins, thus negatively affecting marine ecosystems and fisheries. Gaining a clearer understanding of the molecular mechanisms regulating diatom growth and toxicity is therefore vital for understanding the drivers of bloom dynamics. The importance of biotic interactions in shaping diatom growth and productivity has become increasingly recognized. Further to this, evidence suggests that diatom interactions with other microbes can impact toxin production of toxic diatoms such as *Pseudo-nitzschia*, and thus likely influence the global impact of diatoms in marine ecosystems. Despite the important influence of such interactions on diatom cell biology and metabolism, many of the processes that enable diatoms to regulate acclimation responses to biotic factors remain poorly understood. In this project we aim to combine laboratory and field based approaches to characterize signaling mechanisms mediating interactions between diatoms and bacteria. In particular, using the model diatom *Phaeodactylum tricornutum*, we aim to isolate algicidal bacteria using samples collected from the Western English Channel. We will then employ a novel molecular toolkit that we have developed for *P. tricornutum* that will allow us to characterize the early signalling responses of diatoms to bacteria and/or associated info-chemicals in real time. The longer-term aims of this project are to develop such novel molecular tools for the ecologically abundant, toxic bloom forming diatom *Pseudo-nitzschia*, in order to gain a deeper insight into the biotic drivers of algal population dynamics and toxicity of bloom-forming diatoms.

THE CULTURE COLLECTION OF ALGAE AND PROTOZOA (CCAP): SUPPORTING FUTURE ALGAL RESEARCH AND BIOTECHNOLOGY.

Christine Campbell, Cecilia Rad-Menéndez and Rachel J. Saxon (Scottish Association for Marine Science)

The Culture Collection of Algae and Protozoa (CCAP) is a unique protistan Biological Resource Centre comprising a wide range of biodiversity, from Prokaryotic cyanobacteria to strains from most Eukaryotic lineages. In terms of environmental biodiversity, CCAP strains have been collected from rivers, lakes, oceans and soil; and geographically speaking the strains are equally diverse, collected from every continent from Antarctica to the Arctic regions, from Argyll to the Zambezi. The Collection comprises more than 2500 strains in the public domain of which 345 are Type strains, 967 marine algae, 1299 freshwater algae, and 296 protozoa. CCAP specialises in the isolation, maintenance, identification and distribution of cultures and their associated data, as well as the molecular identification and taxonomic revision of strains. CCAP is also involved in many aspects of protistan science. With protists believed to be making up most of the genetic complexity of our planet's ecosystems, CCAP offers an excellent resource to investigate this diverse and extremely relevant group of organisms. In addition, CCAP is actively involved in algal research and biotechnology. CCAP participates in the GENIALG project by isolating and bio-banking economically important seaweed cultivars, ensuring that the strains and their associated data will be publically available for biotechnological and further research purposes. With the aim of supporting the development of disease management and biosecurity in micro- and macro-algal production facilities, CCAP is developing protocols to isolate, maintain and cryopreserve pathogens of commercially important algae. This effort is enabling considerable improvement in the taxonomy, life cycle and physiology of these poorly known pathogens; accordingly, it supports the design of control methods to eradicate diseases in algal farms. CCAP has focused on the isolation of extreme environment organisms with a collection of polar diatoms and, recently has contributed to a project looking into sea-ice diatom biomarkers.

The diversity and resilience of kelp ecosystems in Ireland

Kenan Chan, Kathryn M. Schoenrock, Aisha M. O'Connor, Stacy A. Krueger-Hadfield, Aaron Golden, Tony O'Callaghan, Rory O'Callaghan, and Anne Marie Power (NUI Galway)*

Kelp ecosystems are changing worldwide via distribution shifts, phase shifts with herbivores or ephemeral algae, or by complete disappearance in response to various climate pressures. The northeast Atlantic is a unique habitat buffeted by an energetic climate system throughout the year and provides a rich seascape for marine communities. European kelp forests are dominated by stipitate Laminariales, specifically *Laminaria hyperborea* from the Mer d'Irlande northwards. We are only just beginning to understand the complex dynamics of these diverse and productive Irish kelp ecosystems in a time in which they are likely undergoing great change. In order to better understand the diversity and resilience within the Irish populations of *L. hyperborea* this project describes i) the historical to present day distribution of subtidal kelp forests along Ireland's coastline, ii) the genetic diversity in populations from the south east of Ireland (hypothesized glacial refugia) to the north (Co. Donegal – Antrim), iii) the presence of kelp propagules in the benthic micro-communities ('spore banks'), and iv) new monitoring tools for continued mapping or reporting for kelp forest communities and phase shifts. These data are important from an academic perspective but are also critical to conservation, regulation or commercial interests.

Haplo-diplontic life cycle enables niche expansion in coccolithophores

*Joost de Vries, Fanny Monteiro (UoB), Glen Wheeler (MBA), Colin Brownlee (MBA)
(University of Bristol (UoB)/ Marine Biological Association (MBA))*

Coccolithophores are most recognizable for their production of intricate calcium carbonate platelets, called 'coccoliths', which lead them to play an important role in the carbon cycle. The production of coccoliths is however not their only striking trait. As haplo-diplontic organisms, coccolithophores are able to reproduce asexually in two different life phases (the 'haploid' and 'diploid' phase). This is in contrast to most phytoplankton, which can reproduce asexually in only the haploid or diploid phase. The haploid and diploid phases of the same coccolithophore species can differ significantly in size, calcification status, and abundance. The two cell forms may furthermore inhabit different niches, which has been proposed to enable niche expansion. To date research has however primarily focused on the diploid life phases, and relatively little is known in regards to the biogeography of the haploid life phase, or how much this phase contributes to coccolithophore abundance and niche space. Through a synthesis of coccolithophore abundance data and literature review, we have investigated the difference in biogeography of the life cycle phases, quantified their relative contributions to global coccolithophore abundance, and determined the contribution of each phase to coccolithophore niche space. Our results show that the two life cycle phases have different environmental preferences and thus inhabit different niches, which allows coccolithophores to expand their niche volume and subsequently increases their total abundance. This research highlights the need to include the haploid life cycle phase in coccolithophore ecology, physiology and climate research, and will pave the way for further studies examining the physiology and ecology of coccolithophore life phases.

Phosphorus dynamics in the Barents Sea

Patrick Downes, Jo Dixon, Claire Widdicombe, Karen Tait (PML / University of Bristol)

The Barents Sea is considered a warming hotspot in the Arctic; elevated sea surface temperatures have been accompanied with increased inflow of Atlantic water to the shelf sea. Such hydrodynamic changes and concomitant reduction of sea ice coverage enables a prolonged phytoplankton growing season, which will inevitably affect nutrient stoichiometry and the controls on primary production. During the 2018 ChAOS cruise to the Barents Sea, we investigated the role of phosphorus in mediating primary production. As its most bioavailable form, dissolved inorganic phosphorus (DIP), had an average turnover time of 12.6 ± 7.4 days. The most southern station (B3) accounted for both the highest rates of primary production ($654.75 \text{ mg C m}^{-2} \text{ d}^{-1}$) and ^{33}P -DIP uptake, where *Emiliana huxleyi* (E.hux) was the dominant phytoplankton species. The fraction of DIP released as dissolved organic phosphorus (DOP) at this station was <4% compared to an average of 27% at all other stations. Station B3 also showed high alkaline phosphatase activity, E.hux are known to synthesise hydrolytic enzymes, utilising the DOP pool when P is limiting. These results suggest warmer waters with prolonged summer coccolithophore blooms could lead to seasonal P limitation which could eventually dominate conditions in the Barents Sea.

Importance of freshwater microalgae and macrophytes in ecotoxicology; use of microbiotests format.

*Emily Eagles, Rachel Benstead, Susan MacDonald, Richard Handy & Thomas H. Hutchinson
(University of Plymouth)*

Research into the freshwater toxicity of chemicals, particularly those of emerging concern, is often dominated by vertebrate studies. To consider the risk of contaminants to the entire ecosystem it is vital to consider all trophic levels, including the primary producers. Zearalenone is a natural toxin formed by fungi of the genus *Fusarium*. As a known endocrine inhibitor recently detected in numerous freshwater studies it is considered a chemical of emerging concern. Freshwater toxicity data for fungal toxins such as zearalenone exist primarily regarding zebrafish, with several investigations into *Lemna* species but very rarely in concern to microalgae. Here we investigate the sensitivity of two primary producers, the microalgae *Pseudokirchneriella subcapitata* and macrophyte *Lemna minor*, to zearalenone using basic growth endpoints and measures of photosynthetic activity. For both test organisms OECD guidelines exist for standardised testing and these were performed in a scaled down microbiotests format. Both the microalgae and the macrophyte demonstrated growth inhibition in the presence of ZON. However the algal species, previously not considered in zearalenone toxicity studies, was 30 times more sensitive than *Lemna*; and when comparing the growth LOEC of the microalgae (230 µg/L at 72 h) to a reported sub lethal LOEC for zebrafish embryos (250 µg/L at 72 h) it demonstrates a similar effect level. As toxic dose is time dependant and varies between species, data for numerous organisms is essential to fully assess potential toxicity to ecosystems. The ability to perform microalgae and *Lemna* sp. tests in a smaller microbiotests format, with commercial kits also available to reduce the cost and time associated with maintaining cultures, offers a relatively easy way to generate commonly overlooked plant toxicity data. Mechanistic toxicity data are also important in understanding the impacts of toxins, with the addition of measures of photosynthetic performance at the end of both tests able to provide the first step in understanding potential sub lethal effects. In the case of this study chlorophyll fluorescence parameters suggested *Lemna* as a potential organism to investigate further with indications of zearalenone inducing electron transport inhibition in PSII of the macrophyte.

Diatoms dominate and alter marine food-webs when CO₂ rises

Jason Hall-Spencer, Ben P. Harvey, Sylvain Agostini, Koetsu Ko, Shigeki Wada (Universities of Plymouth (UK) and Tsukuba (Japan))

Diatoms are so important in ocean food-webs that any human induced changes in their abundance could have major effects on the ecology of our seas. The large chain-forming diatom *Biddulphia biddulphiana* greatly increases in abundance as pCO₂ increases along natural seawater CO₂ gradients in the north Pacific Ocean. In areas with reference levels of pCO₂ it was hard to find, but as seawater carbon dioxide levels rose it replaced seaweeds and became the main habitat-forming species on the seabed. This diatom algal turf supported a marine invertebrate community that was much less diverse and completely differed from the benthic communities found at present-day levels of pCO₂. Seawater CO₂ enrichment stimulated the growth and photosynthetic efficiency of benthic diatoms but it reduced the abundance of calcified grazers, such as gastropods and sea urchins. These observations suggest that ocean acidification will shift photic zone community composition so that coastal food-web structure and ecosystem function are homogenised, simplified and more strongly affected by seasonal algal blooms.

Characterising marine phytoplankton cells by flow cytometry assays

David Hartnell, Adam Lewis, Andrew Turner (Cefas)

Marine phytoplankton account for almost half of global net production, feeding our fisheries and molluscan aquaculture. Numerous species produce potent toxins which have negative human health impacts when bioaccumulated in bivalve shellfish and subsequently harvested for human consumption. Biotoxins in shellfish can take many forms including, paralytic, amnesic and lipophilic (diarrhetic) shellfish poisons; produced by numerous phytoplankton taxa, such as Alexandrium (saxitoxins, spirolides), Pseudo-nitzschia (domoic acid), Gonyaulax (yessotoxins), Dinophysis & Prorocentrum (okadaic acid) amongst others. Consequently, phytoplankton are monitored under European Union food safety legislation (Reg. (EU)2017/625), data are predominantly used as an early warning mechanism to inform toxin testing of shellfish flesh. In the United Kingdom, routine phytoplankton monitoring is undertaken by light microscopy to identify and enumerate cells, following traditional methodologies. Monitoring programmes require skilled taxonomists, are resource intensive and, importantly, morphologically similar species can be toxic or non-toxic; potentially distorting relationships between cell counts and sample toxicity. The development of rapid, targeted methods such as, flow cytometry, flow cams and molecular techniques, that enable identification, enumeration and toxicity would be beneficial to monitoring programmes. Additionally, greater appreciation of phytoplankton physiology, life cycles and toxin production will enhance broader ecological understanding of the role of phytoplankton and their toxins in marine environments. The aim of this study is to develop expertise in flow cytometry (Cytoflex, Becker Coulter) as a tool for the rapid, robust enumeration and speciation of phytoplankton. Work is underway to analyse and characterise those cultures already held at Cefas. Here, data from these strains differentiated by size, auto-fluorescence and staining to assess cell densities, growth rates and cell life stages are presented. Strains where sequence data are available or gathered will be analysed with the objective of selecting nucleic acid sequences for species and toxicity discrimination. This will be used for the development of a fluorescence in situ hybridization (FISH) flow cytometric assay for key species within the monitoring framework.

Development of gene editing technologies within the haptophyte algae

Andrea Highfield, Rowena Stern, Cecilia Balestreri, Jade Hunt, Colin Brownlee and Glen Wheeler (*The Marine Biological Association of the U.K.*)

The haptophytes are a globally distributed group of phytoplankton and are major contributors to primary production and biogeochemical cycles in the oceans. Our understanding of the physiological processes within the haptophytes, such as calcification, is limited due to a lack of robust genetic tools, with only a few reports of genetic transformation in a limited number of species. In this project we have sought to develop a genetic toolbox for key members of this group, including *Isochrysis galbana*, *Pleurochrysis carterae* and *Emiliana huxleyi*, using a range of different approaches. Nuclear transformation using antibiotic-resistant vectors driven by various endogenous promoters have been designed and tested along with different DNA delivery methods. A protocol for CRISPR-Cas9 mediated gene editing is also being attempted using a 'DNA-free' method recently shown to be successful in *Phaeodactylum tricornutum*. Progress made using these methods will be presented.

Blooming blanket weed: managing nuisance algae in National Trust water bodies

Hannah Kemp, Hannah Kemp¹, Suzanne McGowan¹, Alexandra Zieritz¹, Stephen C. Maberly², Carl Hawke³, Martyn Kelly^{1,4}, Stewart Clarke⁵ ¹School of Geography, University of Nottingham, Nottingham, UK ²Lake Ecosystems Group, UK Centre for Ecology & Hydrology, Lancaster Envi (University of Nottingham)

Across the UK, many freshwater ecosystems are experiencing more frequent and widespread blooms of filamentous macroalgae, particularly genera such as *Cladophora*, *Ulva*, *Hydrodictyon* and *Spirogyra*. Currently the extent, cause and consequences of these blooms are largely unknown. The prolific blooms are thought to be associated with increased nutrient concentrations in UK freshwaters from both point source sewage treatment works and diffuse agricultural run-off. However, little is understood about other controls on algae biomass such as interspecies competition, trophic interaction and climate change. The formation of thick mats at the lake surface has the potential to cause major ecological damage by harbouring pathogens, depleting lake water of oxygen and decreasing aquatic plant life. In addition, blanket weed blooms can reduce the amenity value of freshwater bodies by looking unsightly, preventing water-based activities and negatively impacting important conservation work. The National Trust has over 450 lakes on their properties across the UK. Many receive large loads of nutrients from the surrounding land and experience macroalgal blooms which decreases their amenity value for visitors. The lake at National Trust's Clumber Park, Nottinghamshire, will provide a case study site for this project. Routine limnological monitoring and experiments will provide evidence for the main environmental drivers of filamentous macroalgae blooms, and highlight factors causing temporal and inter-annual variability. In addition, simple water quality data and questionnaire surveys gathered from National Trust and other shallow lake sites across the UK, will formulate a better understanding of the extent of the filamentous macroalgae problem. This project is in the early stages of a PhD and has identified gaps in knowledge areas through a detailed literature review. The results obtained from the proposed research aim to inform effective and sustainable techniques for future management and restoration of UK waters with filamentous macroalgae blooms, using the lake at Clumber Park as a model for application elsewhere.

Corallina officinalis on our coastlines, a characterisation.

Regina Kolzenburg, Federica Ragazzola (University of Portsmouth)

Coralline algae are critical components of global marine shallow water ecosystems where they function as important ecosystem engineers. Understanding their physiology is crucial in order to predict future impacts on and potential changes in coastal ecosystems. However, no studies attempted to elucidate the structure of one of the most important members of this order, *Corallina officinalis* (Corallinales, Rhodophyta). By means of a combined approach of field and laboratory analysis, we characterised populations of *C. officinalis* across its geographic distribution in the NE Atlantic from the northern margin, Iceland, to the southern margin, Spain. Structural analysis included tensile strength tests, Laser ablation inductively coupled plasma mass spectrometry, scanning electron microscopy and field transplants. In this way, tensile strength, elasticity, growth rates, cell wall thickness and skeletal Mg/Ca trace elemental ratio measurements were performed. Combining the results of these parameters disentangles the structural integrity of this species and enables predictions of potential future changes as a result of anthropogenic effects such as climatic changes or mechanical stress like trampling. Results showed an elevated cell wall thickness with lower within variability as well as a potential increased elasticity due to lower Mg/Ca ratio in northern margin populations compared to central and southern populations. Additionally, northern populations showed to be able to withstand higher forces and strain before rupture compared to more southern populations. Populations in the centre of the distribution were able to withstand the comparatively lowest forces, southern populations showed the highest deficit in deformation resistance. The observed increased strength and differences in elemental composition of northern populations may be due to local adaptation to harsh environments. Based on these findings, the generally assumed Centre-to-Margin hypothesis regarding abundance as well as adaptation and resilience potential is not observed in structural integrity of *C. officinalis* and is suggested to be modified into a North-to-South gradient for this species. With changing future climatic conditions, central and southern populations might not be able to withstand an increase in extreme weather events. Overall, this study demonstrates that coralline algae (Rhodophyta, Corallinales) are vulnerable to potential future climatic changes.

Differences in acid-base regulation of haploid and diploid life-cycle stages of *Coccolithus braarudii*

Dorothee Kottmeier, Abdesslam Chrachri, Gerald Langer, Glen Wheeler, Colin Brownlee (Marine Biological Association)

Coccolithophores are calcifying microalgae that carry characteristic calcite platelets (coccoliths) on their surfaces. Most coccolithophore species exhibit diploid and haploid life cycle stages, each adjusted to different environmental conditions. Diploid life cycle stages are often heavily calcifying, thereby producing excess amounts of H⁺. Haploid life-cycle stages are often weakly calcifying, generating significantly less H⁺. We show how these different cellular “H⁺ burdens” require substantially different physiological molecular strategies to regulate intracellular pH under changing environmental conditions. We combine physiological measurements with molecular and pharmacological approaches, allowing for the identification and characterisation of membrane proteins involved in pH homeostasis. We also present why the different mechanisms for acid-base regulation result in a more pronounced sensitivity towards ocean acidification in the heavily calcifying diploid life-cycle stage.

Metabolomic and Physiological interactions between a cyanobacterium and a diatom: what regulates a co-existence?

Sandra Lage, Hanna Mazur-Marzec; Elena Gorokhova (Stockholm University)

Nodularia spumigena is a toxic, bloom-forming, and nitrogen-fixing filamentous cyanobacteria occurring in brackish waters worldwide. *N. spumigena* produces several classes of non-ribosomal peptides (NRPs), including hepatotoxic nodularins, that play important roles in shaping plankton communities, although their modes of action are poorly understood. Here, we evaluated whether the interspecific interactions between *N. spumigena* and the diatom *Phaeodactylum tricornutum* affect NRPs production by the cyanobacterium. Using a novel approach that combines culture technique (mono- and co-culturing of the test species) and liquid chromatography-tandem mass spectrometry for NRPs analysis, we quantified internal and external NRPs produced by *N. spumigena*. Additionally, we evaluated growth and photosynthetic activity of both species under mono- and co-culture conditions. In line with previous studies, growth of *P. tricornutum* and the nodularin production by *N. spumigena* were not affected by co-culturing of the diatom and cyanobacterium. However, production of spumigins, another NRP group, was significantly affected under co-culture conditions. In addition, the photosynthetic activity, i.e. effective quantum yield of photosystem II in *P. tricornutum* and *N. spumigena* increased under co-culture conditions compared to the monocultures. As spumigins are potent inhibitors of serine proteases, which contribute to functioning of photosynthetic apparatus, it is possible that these NRPs are involved in interspecific competitive interactions via photosynthesis regulation.

Pre-emptively assessing HAB risk, can we anticipate impacts from climate driven invasions?

Adam Lewis, Andrew Turner, Linda Percy, Jane Lewis (Cefas/University of Westminster)

Climate change is facilitating changes in the distribution of many species globally, including microalgae. Harmful marine microalgae can have a range of impacts on ecosystems and human health as a result of toxin production, creation of hypoxic conditions and mechanical damage to other marine organisms. Due to these deleterious impacts harmful taxa are of great interest although they constitute a comparatively small proportion of the known microalgal species. Monitoring efforts and, in some cases, mitigation strategies have been implemented in many regions where harmful species are known to occur. These efforts are designed to limit the impact of the locally relevant harmful species but are often so targeted in nature that they do not offer protection against threats or impacts from unexpected harmful species. Within the UK a robust monitoring programme is established to determine the presence of toxin producing microalgal species as well as to quantify the presence of toxins within bivalve shellfish destined for human consumption. This monitoring effort targets five groups of toxins regulated within the EU. However, with shifting environmental conditions and a globally connected ocean this targeted monitoring will need to adapt to changes in risk, or damage to public health and the environment is likely to occur without warning. The occurrence of a new harmful microalgal species in the UK could be determined by quantifying the impact of such an introduction after it has taken place. In order to achieve this, new methods may need to be established for the determination of toxin presence or species identification with a consequent delay in management. Alternatively, it may be possible to assess the likelihood of a species introduction or range expansion and to prepare ahead of an event. In the spirit of this approach, work is underway to assess the risk posed by over 120 harmful species from sources worldwide but not yet known from UK shores. Here we present a methodology for evaluating risk as well as exploring possible routes of introduction, future ocean climate projections and challenges associated with certain harmful taxa.

Insights into phytoplankton assemblages using Mesolens microscopy

Deirdre McLachlan, Serena Flori, Katherine Helliwell, Glen Wheeler & Colin Brownlee (The Marine Biological Association)

Most investigations of unicellular algae are limited to a specific scale - we can examine population level responses and single cell responses, but not at the same time. Studies of single cells are carried out with high magnification microscopes that allow detailed imaging of only a few cells. Until recently, simultaneous imaging of large numbers of cells in a population has required a trade-off between wide field of view, obtained with a low magnification objective, and optical resolution, or the ability to see fine detail in the image. This major limitation has recently been overcome through a novel concept in optical imaging that allows wide-field imaging with exceptionally high resolution. The Mesolens uniquely combines wide-field, low magnification (x4) with high resolution (n.a. = 0.5), aberration-free images, representing a revolution in optical imaging, providing sub-micron lateral resolution wide-field (up to 6mm diameter) images. This allows us to simultaneously examine stimulus-induced responses in a population of tens of thousands of cells, and also the individual responses of the cells within that population. Using *Phaeodactylum tricornutum* transformed with the calcium sensor R-GECO, we have examined calcium dynamics at the population level and also the responses of the individual cells within that population. We also demonstrate the utility of this approach for studying physiological properties of single cells in natural mixed phytoplankton populations.

High resolution pocket microscope with display on mobile phone

Andrew Monk, None (*ioLight magnificent Mobile Microscopes*)

The State of New York has approximately 1,200 lakes, managed by 300 Lake Associations. These are made up of residents living on the shores of the lake who have a strong interest in maintaining the health of their lake. Changes in climate and farming methods have led to an increase in toxic Harmful Algal Blooms (HAB). Suspect algal blooms must be reported to the Environmental Protection Agency, which issues a 303(d) status of impaired water notice, closing the lake to recreational activities. Prof. Greg Boyer of SUNY Environmental Science and Forestry says that many of these blooms are in fact harmless, but diagnosis requires a microscope. Lake Association members often drive long distances to Prof. Boyer's Lab in Syracuse NY to have their samples checked so that their lake can be re-opened. The ESF team is trialling the ioLight portable microscope, a pocket sized instrument that allows Lake Associations to capture high-resolution microscope images of the algae on their mobile phones and instantly send them to ESF for analysis. ioLight is presenting demonstrations of its Magnificent Mobile Microscope in the British Phycological Society Conference and invites you to see how you can capture and share beautiful images of algae directly from the water's edge. We hope that Lake Associations in New York State can now spend their weekends on the lake rather than driving to Syracuse and back. [Note: our presentation is a demonstration, not a poster. Following a discussion with Prof Jason Hall-Spencer, we would like a 3-minute slot to promote the demonstration]

The colour dynamics and photosynthetic performance of the brown alga *Cystoseira tamariscifolia*

Barry Pettifor, Supervised by - Rasmusson, Lina M.; Hall-Spencer, Jason M. (Plymouth University)

Structural colours are seen when nanoscale anatomical features interfere with incident light at particular wavelengths which are then reflected. Iridescence occurs when changes in viewing angle alter the colour perceived. This has evolved biological uses in signalling (e.g. in plants, insects, birds) and light harvesting (angiosperms). In some marine algae colour is created by extracellular multilayer structures or intracellular, tightly packed nanospheres. Recent research on the brown seaweed *Cystoseira tamariscifolia* revealed the opalescent photonic crystal (OPC) anatomy responsible for this species' blue colouration and showed that its colour intensity responds to light and dark. Biophysical modelling led to speculation that OPCs have a role in photosynthesis. To investigate this further we explored colour responses in *C. tamariscifolia* using time lapse photography and a range of light treatments. The most intense blue colouration occurred in the dark and reduced rapidly in light, even at very low irradiance levels. The response was not light spectrum dependent, such as might occur in response to immersion. Chlorophyll fluorometry showed that the maximum quantum efficiency of photosystem II was higher in conditions in which strong blue colouration was evident (just after dark) but reduced over a 90 minute period of illumination. Dynamic nanostructures may modulate the transmission of light to chloroplasts in response to different irradiance levels. In terms of practical applications, static nanostructures have already been shown to enhance the efficiency of photovoltaic cells. A deeper understanding of the sensing and motor processes used to manipulate light transmission in seaweeds could inform solar cell design through incorporation of self-tuning mechanisms.

Drivers and drainers of oxygen consumption in the temperate seagrass *Zostera marina*.

Lina Rasmusson, Martin Gullström, Mats Björk (University of Gotheburg)

The seagrass *Zostera marina* creates highly important habitats in temperate coastal areas offering several ecosystem services essential for a thriving ocean. Through their high photosynthetic efficiency vast amounts of carbon dioxide are taken up and at the same time partially respired back to the water column; therefore seagrass productivity might impose a great impact on coastal carbon- and oxygen fluxes. Photosynthesis is well studied in *Z. marina*, however, respiration has been given less attention. In earlier studies, respiratory rates have been obtained in darkness and used as a constant over the day, a consensus that we have found misleading. Here, we present a comprehensive assessment of the factors involved in affecting respiration rates. The results showed that light seems to have a suppressive action on the respiratory machinery as we found a high reduction in respiratory rates in light. Furthermore, the dark respiration rates appear to be highly fluctuating on a diel basis, with peaks during mid-day when productivity is at its highest level and at night. Moreover, the temperature was shown to have a major impact on seagrass respiration (confirming earlier research). Finally, as many ecological climate models use a Q₁₀ of two for metabolic processes, we wanted to test if this was accurate for seagrass respiration and photosynthesis. Values fluctuated greatly depending on initial temperatures and depending on the temperature range chosen, indicating that a constant Q₁₀ of two is not precise. These findings clearly show that to make accurate assessments of oxygen- and carbon fluctuations in shallow coastal seagrass areas, a variety of factors needs to be taken into account.

Manton Prize

Macrocystis pyrifera in a warming ocean – a lab experiment in Chile

Nora Salland, Martín Munizaga Kappes, Martin Thiel, Mark Lenz (*Marine Biological Association*)

In northern-central Chile, natural variability in ocean temperature is driven by the El Niño Southern Oscillation (ENSO). The frequency and intensity of ENSO events and resulting heat waves may increase in future due to anthropogenic climate change. Kelps are important primary producers in coastal temperate ecosystems. They serve as a food source for many marine invertebrates and, as ecosystem engineers, provide habitat, nursery and foraging grounds for a wealth of associated fauna. *Macrocystis pyrifera*, the giant kelp, is a cold-adapted species abundant along the Chilean coast where it plays a critical role in the food web and acts as a habitat former in the coastal ecosystem. In laboratory microcosms, we examined the influence of ocean warming on young *M. pyrifera* sporophytes (121 ± 23 mm blade length). The performance of the alga was assessed across a range of temperatures from the present day annual mean temperature in Coquimbo, Chile (14°C) to the predicted average temperature in the year 2100 (22°C ; IPCC 2014). In a simultaneous two-factorial experiment we measured kelp growth at temperature intervals and under grazing pressure by the red sea urchin *Loxechinus albus* and the black sea urchin *Tetrapygus niger*. Algal growth rates were a unimodal function of temperature, with maximal growth rates of 2.14 mm/day at 17°C . This temperature for optimal performance is below the present day average summer temperature in the Coquimbo region (18°C). At 20°C the young *M. pyrifera* sporophytes showed no significant reduction of growth. This is contrary to the literature, where growth of large sporophytes is limited at this temperature. At 21°C and 22°C we observed tissue loss and mortality in some sporophytes. Results of the two-factorial experiment showed no significant interaction effect between temperature and grazing pressure by sea urchins on elongation of *M. pyrifera*, which suggests that the kelp shows no compensatory growth due to herbivory grazing. Based on our findings, we predict that near-future summer temperatures and heat stress caused by ENSO will have detrimental effects on *M. pyrifera*, with consequences for associated biodiversity and communities, since the temperature of maximal growth is already commonly exceeded during the austral summer.

Thermal tolerance of *Laminaria digitata* gametophytes suggest subtle population differences

Nele Schimpf, Kiara Franke, Daniel Liesner, Michael Roleda, Inka Bartsch (University of Plymouth and Alfred-Wegener-Institute)

Kelps form highly productive and structurally complex marine forests along rocky coastlines in the North Atlantic, but globally they are at risk of decline at their trailing edges due to climate change. The majority of studies have focused on the ecology and thermal responses of the macroscopic sporophyte phase of kelps. In *Laminaria digitata*, the microscopic gametophytes generally withstand a 2-3°C higher temperature than sporophytes. Thereby, they provide ecologically important and hardy seed banks. If local temperatures surpass the upper survival threshold of gametophytes, for example at southern locations, populations might face extinction. We hypothesized that local differentiation in the gametophyte heat tolerance of *L. digitata* corresponds to the long-term local temperature history. Therefore, we performed a full-factorial temperature experiment on gametophytes sampled along a latitudinal gradient, from Quiberon, France (southern geographical and temperature limit), Helgoland, Germany (temperature limit) and Bodø, Norway (cold-temperate location). Vegetatively grown gametophytes were derived from spores released by multiple parental sporophytes, and were exposed to a temperature gradient (20-25°C) for two weeks and post-cultivated at 15 or 20°C for further two weeks. Cell pigmentation and presence of growing cells were used as a proxy for survival. Change in gametophyte density and the ratio of male to female gametophytes were analysed. Gametophytes from all populations were able to survive 15- 23°C, subtle differences were apparent at 24°C, and 25°C was lethal for all. In the Bodø population, 24°C was lethal after two weeks. In the Helgoland population, 7.6 % gametophytes survived 24°C for two weeks, but were dead after two weeks of post-cultivation. In the Quiberon population, 2.3 % gametophytes survived 24°C for two weeks and survival rate remained the same during post-cultivation. Interestingly, long-term post-cultivation (6-12 weeks) revealed that a few gametophytes were able to regenerate. In general, considerably more males than females survived with increasing temperature. Current sea surface temperatures at the studied locations generally do not reach the lethal limit of the gametophytes tested in this study. Nonetheless, we found indications for subtle local adaptation in the lethal upper temperature limit following the latitudinal gradient.

Exploring the Microphytobenthos in the Intertidal Thames

Dain Son, Dr. Susi Arnott and Prof. Jane Lewis (University of Westminster)

Developing a science art partnership, aspects of the changes observable in a Thames mudflat were investigated. The variation of colour on mudflats over two tidal cycles in June were observed and recorded using time lapse filming. Alongside this the microphytobenthos (MPB) was sampled and analysed by light microscopy to determine the principal components of the community which were diatoms and euglenids. These were counted and their volumes determined. Euglenids dominated diatoms in terms of numbers and volumes on both sampling days, although the proportions varied for the different days. Colour analysis of film segments related to the sampling sites showed that colour make up was very similar across the sampling points but 'hue' was related to the proportion of euglenids in the community. It is possible that within one site, limited detailed microscopical analysis, combined with filming might be an effective method of scaling up observations of these habitats which can be otherwise challenging to document.

Investigation of a spring potamoplankton bloom using light microscopy and flow cytometry

Peter Vaughan, None (University College London)

Phytoplankton growth in lake ecosystems has been extensively studied and is relatively well understood. In contrast phytoplankton growth in rivers (potamoplankton) has received less attention and the factors which drive it, in particular seasonal succession, are less elucidated. This study investigated the dynamics of the 2019 Spring phytoplankton bloom in the River Thames using weekly flow cytometry (FCM) and light microscopy (LM) analysis to identify and quantify the types of phytoplankton present, together with measurements of chlorophyll-a and physicochemical parameters. This was the first time that FCM and LM methods had been used together to study a potamoplankton bloom, and provided a more complete picture of changes in the phytoplankton community composition than had previously been achieved using either method individually. The study also enabled a comparison of the utility of the two methods. LM analysis identified individual phytoplankton groups based on their detailed morphology. It indicated that the 2019 Spring bloom was dominated by centric diatoms, as found for previous studies of phytoplankton blooms in rivers, but also revealed a major euglenophyte component, which had not been previously reported. There were also large numbers of cryptophyte cells and, after the centric diatoms had declined, successive peaks in chlorophytes and dinoflagellates. FCM analysis identified phytoplankton groups based on their size and fluorescence (pigment) properties. It had a lower taxonomic resolution than LM but, as an automated system, was much quicker and required less operator training. FCM was also able to detect cells below the effective lower size limit for LM analysis. Such cells, i.e. pico- and nano-chlorophytes, greatly outnumbered the cells counted by LM, both during and after the peak bloom. There were some linkages observed between the population dynamics of individual phytoplankton groups and some of the physicochemical factors measured, but the post-peak decline in the 2019 phytoplankton bloom did not appear to be related to changes in any of these parameters, including water temperature, river flow-rate, sunshine hours or nutrient concentrations. The factors limiting potamoplankton blooms are not well understood and future research might look at the potential role of biotic influences such as predation and viral-induced mortality.

Using Herbarium Collections to Improve our Understanding of an Important Group of Red Algae

Georgia Ward, Dr Janina Brakel, Professor Juliet Brodie (Natural History Museum)

Eucheumatoid red algae (*Kappaphycus* and *Eucheuma* spp.) are among the most valuable of cultivated seaweeds, and are commercially exploited for their high carrageenan content. Much of this production is in Southeast Asia, in particular Indonesia, the Philippines and Malaysia, and eucheumatoid cultivation is becoming increasingly economically important in East Africa, specifically Tanzania. Despite their economic significance, the taxonomy of the group remains poorly resolved. There are currently 30 valid eucheumatoid species across four genera (*Eucheuma*, *Eucheumatopsis*, *Kappaphycus* and *Betaphycus*), however the majority of available sequence data are for a small handful of commercially cultivated species and varieties, or are otherwise from taxa within this same geographical region, where there is dedicated research effort and expertise. Natural history collections and herbaria are increasingly being seen as valuable resources for taxonomy studies and have the potential to act as an extensive source of molecular, phenotypic and biogeographic data for specimens across broad temporal and spatial ranges. In order to further our understanding of eucheumatoid taxonomy, and provide the most complete phylogeny of the group to date, we sequenced the mitochondrial Cox 2-3 spacer region and regions of the plastid *rbcL* gene from specimens held at the Natural History Museum in London, UK, including 17 purported species (eight of which previously had no available sequence data), from 17 countries across the Americas, Asia and Africa.

Innovative approaches to seaweed cultivation: optimising species selection and culture strategies

Catherine Wilding, (Marine Biological Association of the UK)

The cultivation of macroalgae is an emerging field in the UK and across Europe. Cultivated biomass of the kelp *Saccharina latissima* has value as a human food, animal feed, and bioremediator, as well as potential for carbon sequestration and biofuel production. A recently developed 'bio-binder' glue allows for direct seeding of algal gametophytes onto cultivation lines, bypassing the need for a costly hatchery grow-out period necessitated by traditional 'twining' methods. However, the most effective technique for application of binder solution has yet to be optimised, particularly for deployment at sea under high-energy, dynamic conditions. Further research is also needed to optimise seeding density, species selection, seeding technique, and harvest time to maximise yield and economic feasibility. Here we trialled two different direct seeding techniques with three densities of *Saccharina latissima* gametophyte suspension. A one-stage technique involved mixing gametophytes and binder solution together prior to application onto cultivation lines, while a two-stage technique involved application of gametophytes to lines prior to coating with binder solution. Gametophytes were applied at three density concentrations by diluting a cultured gametophyte suspension with seawater, to produce high (4.9 mL m⁻¹), standard (2.45 mL m⁻¹), and low (1.23 mL m⁻¹) density treatments. Seeded cultivation lines were deployed in at sea and cultured in the laboratory: 10m long vertical dropper lines were deployed at a seaweed farm in Porthallow, Cornwall; 80cm lines were cultured in tanks in Plymouth. Following deployment during November 2019 lines will be monitored for sporophyte growth rate, density, biomass and biofouling. Species diversification will also be explored through trial culture and economic feasibility assessment of two new species: the Golden kelp *Laminaria ochroleuca* and Furbelows *Saccorhiza polyschides*.

Potential impact of combined environmental stressors on UK intertidal macroalgae.

*Gracie Wilson, Dr Andrew Blight, , Professor Michael Burrows, Professor David Paterson
(University of St Andrews)*

Intertidal macroalgae are ecologically important primary producers. They are also key indicators of how climate change will impact coastal zones. Under current climate change predictions, macroalgal species will have to either adapt to the new conditions, change their distribution, or face extinction. In order to predict what may happen to the UK's most dominant intertidal macroalgal species, this project will investigate the single and combined effects that selected environmental stressors, in various orders and combinations, may have. The stressors of interest to this project include but are not limited to increasing sea temperature, eutrophication, and ocean acidification. Dominant species of interest include intertidal red, green and brown macroalgae from across the intertidal zones. Special interest will be given to species which are currently being harvested within the UK. Using the new state of the art facilities within the Scottish Oceans Institute at St Andrews University, the laboratory experiments will consist of a tidal system where independent mesocosms will be manipulated to investigate the impact of the defined stressors. This impact will be examined by monitoring growth rates, photosynthetic activity, chlorophyll content and recording both wet and dry weight. The laboratory experiments will establish the species that are most sensitive and the combination of stressors that have the greatest effects. This work will then be used to consider the impact of stressors on these algae under natural conditions.

Optimising strain selection and developing a biorefinery for industrially relevant microalgae

Eleanor Wood, (SAMS)

Production of algal biomass for specific products is a costly procedure that often leads to waste in the form of disrupted biomass or water. The larger components of the algal biomass such as proteins, lipids, and carbohydrates tend to hold less value than the specific amino acids, fatty acids or polysaccharides that they are composed of. To make algal production more feasible biorefinery; the production of three or more products from the algal biomass, is necessary to maximise value from the cultivation process. This project aims to identify the highest value products within the cells of different algal species under varying conditions using analytical techniques such as GCMS and HPLC. Following this, high value components such as pigments, peptides or fatty acids, that can be used for pharmaceuticals or cosmetics, will be separated from the rest of the biomass using cell disruption and purification techniques. Remaining biomass will be used for further products such as feed or fertilisers. Photobioreactors from 1L to 1000L with submersible LED technology from Xanthella will be used so that successful small scale experiments can be upscaled to a commercial level.

Sequestration of carbon from Laminaria kelp forests may be diminished in a warmer climate

Luka Wright, Andy Foggo (University of Plymouth/Marine Biological Association)

Among the services provided by kelp forests, their contribution to blue carbon sinks is currently of utmost relevance. Detritus from these fast-growing plants, together with assimilated carbon, is sequestered into sediments. Along the Northeast Atlantic coast, the predominant kelps are of the genus *Laminaria*. While the cold-adapted *L. digitata* (Ld) and *L. hyperborea* (Lh) are shifting northward, the warm-adapted *L. ochroleuca* (Lo) is currently expanding its range due to climate change. This study aimed to compare photosynthetic performance and decomposition between the three *Laminaria* spp. in order to better understand whether the contribution of kelp forests to carbon sequestration is altered in a warmer climate. Detritus from all species was aged in a litter bag field experiment. Weight, chlorophyll fluorescence, respiration and net primary productivity were measured before deployment and after 25 and 32 days at sea. Moreover, lamina discolouration was quantified using imaging software. First, Lo detritus lost biomass at a faster rate than that of cold-adapted species. Second, operating efficiency of PSII declined in all species after 32 days, being highest in Lh and lowest in Lo. Third, gross primary productivity remained constant over time in the northern species, while it decreased in Lo, which was net respiring after 32 days. Fourth, detritus of Lo had a larger proportion of lamina discolouration than the two cold-adapted species after 32 days. The faster decomposition of Lo detritus and its lower photosynthetic performance suggest a decreased carbon export and sequestration potential. Considering that in the near future Lo will become the dominant kelp in the Northeast Atlantic, climate change will likely reduce the carbon sequestration function of temperate kelp forests – a vicious circle, which further exacerbates the effect of anthropogenic carbon emissions. This study hopes to inform climate mitigation strategies and emphasises the need to protect cold-adapted kelps as they are driven north with rising temperatures.

Chloroplast genome variability of *Corallina officinalis*

Chris Yesson, Xueni Bian, Chris Williamson, Juliet Brodie (Zoological Society of London)

Corallina officinalis is a calcifying red algae, common in tide pools in the North Atlantic. It is an important habitat forming algae, providing shelter and substrate to many other organisms. There are few published genomes for this group. This study reports the first four published plastomes for this species, along with 3 new mitogenomes from samples in UK, Spain and Iceland. The plastome is 178kbp and shows 99.9% of bases are identical for all samples. The mitogenome is more variable than the plastome. Structure and length of both genomes is consistent with other published *Corallina* genomes.

The comeback of Rhodophyta to the Gulf of Gdańsk (southern Baltic Sea)

Aleksandra Zgrundo, Ilona Złoch (*University of Gdańsk*)

The Gulf of Gdansk has been significantly degraded as a result of extensive exploitation of marketable species (plants and fish) from 1960 to 1980 and strong eutrophication limiting the growth of marine organisms. Despite this, it is still considered as a region of exceptional environmental values and high biodiversity in comparison with adjacent regions. In 2004, a Natura 2000 site was created in the Puck Bay and actions were taken to protect endangered habitats and species. Concurrently, projects were started to restore the species of plants considered extinct and endangered, for example, *Fucus vesiculosus* L and *Zostera marina*. In August and September 2019, intensive field studies were conducted in the Puck Bay on flora (micro- and macroalgae and flowering plants) to assess biodiversity and habitats resources. The material was collected for qualitative and quantitative analysis according to recommendations of Helcom Combine (Part C, Annex C9). This allowed observation of species that have not been reported since the 70s, i.e. *Furcellaria lumbricalis* (Hudson) J.V.Lamouroux and *Coccotylus brodiei* (Turner) Kützing. The identification of *C. brodiei* still requires confirmation because specimens from brackish gulf waters morphologically do not fully exhibit features of the forms developing in the saline waters, and there is a lack of reference material in local collections. Both species were present in the form of free-flowing thalluses in areas where the bottom was covered with 100% flora. This free-flowing form of growth was characteristic for populations observed up to the 60s and they were usually observed together. This imposes a question – whether the observations indicate improvement in the environment quality due to declining human pressure or observations were the result of the extensive studies. The last intensive flora studies have been performed in the early 2000s. Currently, the national monitoring of macroalgae and flowering plants in the Puck Bay is being conducted on a short transect located at the opposite end of the bay. In the presentation, we will expand on issues related to the the indicative potential of naturally recovering populations considered to be extinct.

KEYNOTE SPEAKERS

Prof Gregory Beaugrand



Gregory Beaugrand works on the effects of climate change on marine biodiversity at large spatial and temporal scales. He is developing the MacroEcological Theory on the Arrangement of Life (METAL) to understand, unify and predict patterns observed in biogeography and climate change biology.

Dr Irene Olivé

Irene Olivé is a marine scientist studying the ecology of macrophyte benthic communities, particularly seagrasses. Her main interest is to study the ecophysiology of coastal macrophyte communities and their capacity to acclimate and adapt to environmental forcing caused by human activities and climate change. Her current research addresses the single and combined effects of climate drivers, such as CO₂, temperature and hypoxia, on seagrasses, exploring their impact on carbon balances and the functioning of the associated community.



She combines methods from physiology, molecular biology, population ecology, and oceanography, following a scaling-up approach from individuals up to community. Her research combines laboratory and field experiments using natural locations that recreate future expected climate change scenarios (e.g. CO₂ vents, upwelling areas). She has been working on seagrass communities in the Mediterranean, Atlantic, Pacific and Indian oceans.

Dr. Olivé received her BSc and PhD degree in Marine Sciences from the University of Cadiz (Spain). She is currently working as a Marie Curie postdoctoral fellow at the University of Glasgow. Previously, she worked as a postdoctoral researcher at the Spanish Research Council (CSIC-Spain), the National Autonomous University of Mexico (UNAM-Mexico) and the Portuguese Centre of Marine Sciences (CCMar-Portugal).

Dr Pippa Moore – pim2@aber.ac.uk



Pippa Moore is a marine community ecologist who is interested in all aspects of marine ecology and more specifically on how algal-dominated near-shore ecosystems are structured and function. Her research has generally focussed on the consequences of climate change (global warming and ocean acidification) and other anthropogenic impacts (e.g. fishing, off-shore engineering, invasive species) on populations and communities of intertidal (rocky shores) and shallow subtidal systems (kelp forests and seagrass).

Dr Sebastian Hess

Sebastian studied Biology at the University of Bonn (Germany) with a focus of limnology and plant cell biology (2005-2011). During that time, he (also being an enthusiastic microscopist) discovered the intriguing world of parasitoid protists feeding on microalgae, which eventually led to his PhD research in the laboratory of Michael Melkonian at the University Cologne. From 2012 to 2014 he studied several groups of phagotrophic protists and their interactions with microalgae with a focus on taxonomy, phylogenetics and ultrastructure. This was followed by a 3-year research stay as an independent research fellow (2015-2018; funded by the German Research Foundation) in the laboratories of Alastair Simpson and Andrew Roger at Dalhousie University (Halifax, Canada). In Halifax Sebastian and his colleagues explored differential gene expression in algivorous microbes with RNAseq and made first steps towards testing for enzymatic activities in these organisms. Early 2019 Sebastian acquired the prestigious 'Emmy Noether' funding by the German Research foundation to start his own research laboratory at the Institute of Zoology of the University of Cologne.



Dr Fabrice Not



I obtained my PhD in plankton ecology in 2004 at the University Pierre and Marie Curie (now Sorbonne University). After a post-doc at RSMAS (Univ of Miami, USA) and at the Institut de Ciències del Mar (CISC Barcelona, Spain), I joined the CNRS at the Station Biologique de Roscoff (France) in 2008. Senior Scientist, I'm currently head of the research department "Adaptation and Diversity in Marine Environment". I participated to more than 29 research projects, among which 12 as Principal Investigator, and contributed to more than 80 scientific publications.

As a biological oceanographer I use primarily molecular tools to investigate plankton diversity and ecology. My research interests focus on biotic interactions between planktonic organisms and more specifically the photosymbiotic relationships between large unicellular zooplankton and microalgae. In the last decade I have been performing sampling cruises, single cell sorting, cell culturing, single cell molecular barcoding and transcriptomic approaches on symbiotic and non-symbiotic organisms belonging to the Radiolaria lineage essentially. I also contributed to the development of bioinformatic tools such as Sequence Similarity Network to compare large and complex datasets. Combining these approaches with experimental physiology and microscopy I try to understand what are the fundamental biological processes involved in plankton photosymbiosis and what is the role of such interactions in oceanic ecosystems.

Dr Alexandra Campbell

Dr. Alexandra Campbell joined USC in February 2018. Alex is an award-winning marine ecologist who combines field ecology with environmental microbiology, natural products chemistry and environmental science to answer questions about how environmental change influences interactions between important marine organisms and the things that consume, infect or live on them. She is particularly interested in macro-micro interactions and how these influence host health and ecosystem function. She is passionate about ecological conservation and restoration and increasingly interested in how human health and wellbeing are linked to ecosystem function in the marine realm. Alex believes that effective science communication is essential for conservation and the future of science and is actively engaged in outreach activities to bring science into everyday life.



Prior to joining USC, she worked as a Research Associate at UNSW, with visiting fellowships at the University of Western Australia and Nanyang Technical University in Singapore.

Martyn Kelly



Martyn is an environmental consultant and Honorary Professor at Nottingham University. For the past 20 years he has been working on the implementation of the Water Framework Directive, developing algal-based methods for assessing ecological status in lakes and rivers. He co-ordinated the European Commission's phytobenthos intercalibration exercise, to ensure a common level of ambition in WFD implementation throughout Europe and, more recently, has helped to develop a handbook of best practice for setting nutrient targets to support good ecological status. He is editor of *Freshwater Benthic Diatoms of Central Europe* and is a contributor to the Diatom Flora of Britain and Ireland (<https://naturalhistory.museumwales.ac.uk/diatoms/>). His blog about the ecology and natural history of freshwater algae can be found at www.microscopesandmonsters.wordpress.com

Dr Mike Best

Mike is the Senior Marine Advisor for the Estuarine and Coastal Monitoring and Assessment Service, within the Environment Agency. Mike is responsible for the development of marine plant (phytoplankton, macroalgae, seagrass & saltmarsh), microbial, and eutrophication tools and indicators for various assessments in coastal and estuarine environments and their associated monitoring programs. Additionally his team has developed screening tools to assess human impacts from developments.

Mike led the UK Marine Plants Task team for developing marine tools for water framework directive (WFD); and led the North East Atlantic marine plants intercalibration group and NEA Phytoplankton group. He is a member of the UK Pelagic Habitats Expert Group. He is a technical advisor for the impact of Nitrate Vulnerable Zones (NVZs) on marine waters, and for designating Sensitive and Polluted areas under the Urban Waste Water Treatment (UWWTD) and Nitrates (ND). Mike's team develops tools to help objectively weigh the conflicting evidence from these different sources of information.

Over the years Mike has produced numerous internal & external publications, reports and educational materials on a wide range of subjects from the physiology and ecology of feeding in intertidal marine bryozoan, seabird feeding behaviour, bathing and shellfish waters health, wildlife of the Humber estuary, eutrophication and nutrient studies; UK phytoplankton, rocky shore macroalgae, soft shore nuisance green algae, seagrass and saltmarsh; assessments of power stations and Sewage treatment works, and toxic chemicals loads to sea.



Dr Chris Yesson – chris.yesson@ioz.ac.uk



Chris Yesson is a research fellow at the Institute of Zoology, Zoological Society of London. His research is focussed on benthic ecology with a particular focus on coral and seaweeds from the north atlantic. He is investigating the impact of trawling on the seabed in West Greenland, by surveying, documenting and analysing the benthic diversity of the region. He is researching the distribution, abundance and genetic connectivity habitat forming seaweeds around the UK. Find out more at <https://macroalgalresearchgroup/>

Prof Graham Underwood

Graham Underwood is a Professor in the School of Life Sciences at the University of Essex. Trained as a zoologist (University of Reading), and with a PhD in freshwater ecology

(University of Sussex), he moved to Essex in 1992, after a period of post-doctoral work at the University of Bristol. His research covers freshwater, estuarine, coastal and shallow sea, and sea ice biology and ecology, with a major focus on microbial ecology, dissolved organic matter and biogeochemical cycling, and ecosystem functioning. Though based primarily in the U.K., he has also carried out research in the Baltic, Mediterranean and South African environments, tropical systems in the Indo-pacific and the Bahamas, in Antarctic and Arctic sea ice, and high latitude lakes (Greenland). He was a member of the DEFRA science advisory panel on marine conservation zones (2009-2012), and sits on various Environment Agency statutory committees. He is currently President of the British Phycological Society (2018-2020), was Chair of the U.K. Natural Environment Research Council (NERC) Strategic Programmes Advisory Group (SPAG) from 2014-2019, and has just been appointed the Chair of the NERC Science Committee (2019-2021).



SOCIAL PROGRAMME

Monday 6th January 17:00

Registration and drinks reception at the Marine Biological Association, Citadel Hill, Plymouth.

Delegates are invited to join us at the Marine Biological Association for the icebreaker drinks reception, giving you the opportunity to meet other delegates.



Wednesday 8th January 19:30 – 23:00

Buffet Dinner and Ceilidh, The Loft, Sutton Harbour, Plymouth

Delegates are invited to eat, drink and be merry while enjoying the musical delights of the English barn dance band *Fox Amongst the Chickens*



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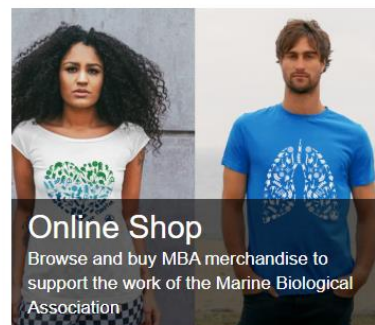
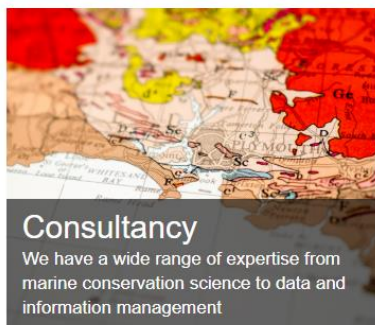
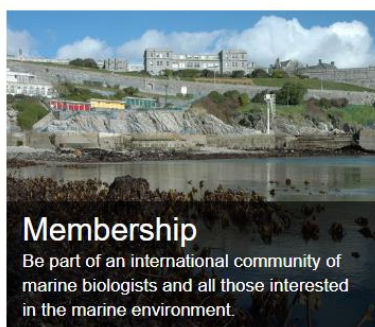
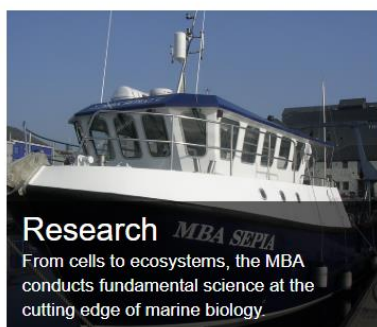
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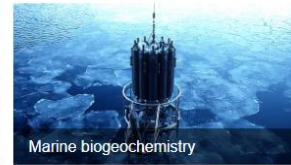
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This link <https://www.plymouth.ac.uk/research/institutes/marine-institute> provides information about the scope and the relevance of the research and facilities the Marine Institute represents and the University's marine education and innovation activities. Together with our partners, we are responding to the challenge of providing science, education, technological innovation and business leadership for tomorrow's world.

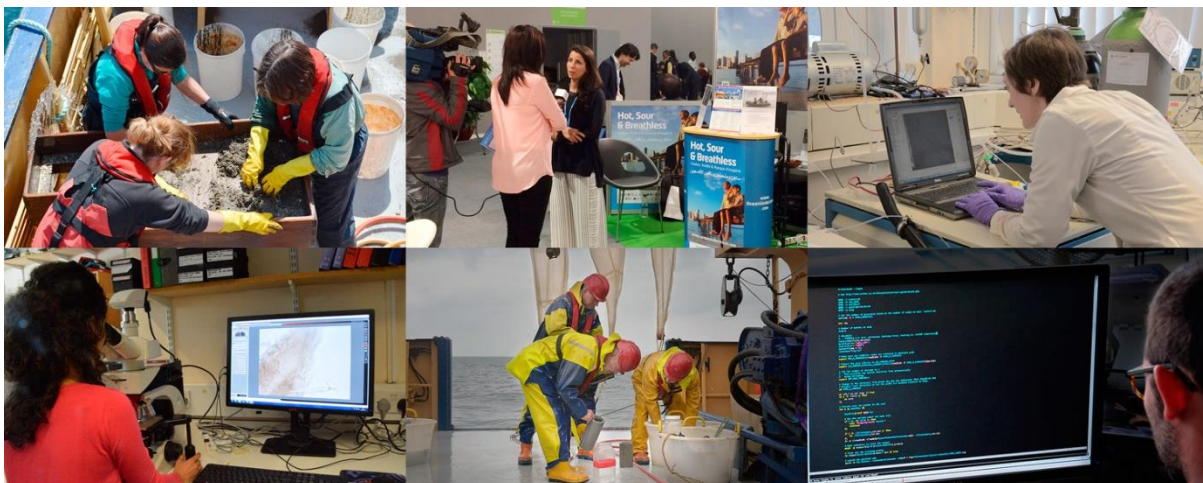
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The impact of our science is far-reaching ranging from highly cited scientific papers, to providing scientific evidence for policy and training the next generation of marine scientists. Through the delivery of our science plan we are also contributing to UN Sustainable Development Goals to promote healthy, productive and resilient oceans and seas. We also have a commercial trading subsidiary, PML Applications Ltd, which delivers services, products and solutions related to the marine environment in key sectors such as ballast water management and biofouling.

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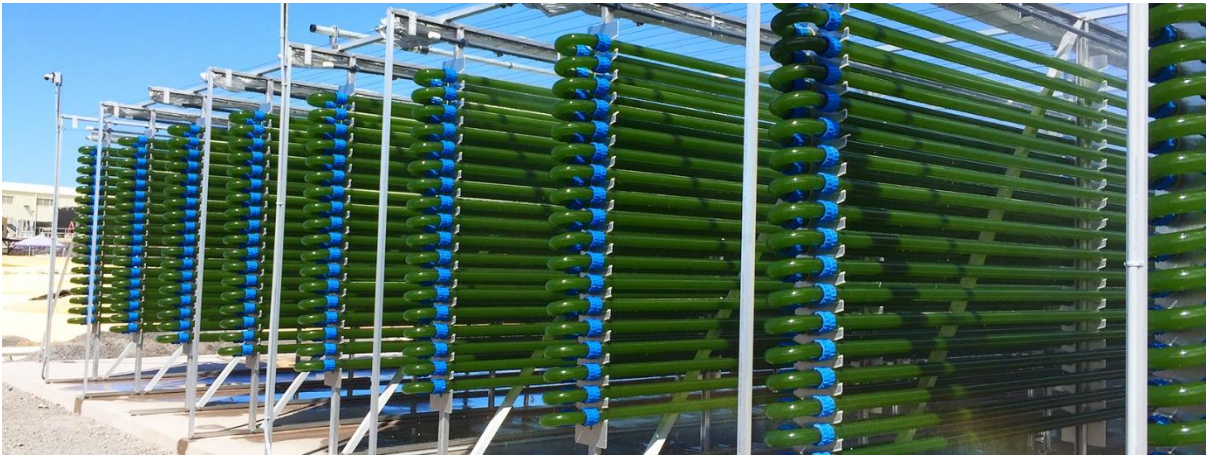
AlgaeCytes Ltd is a UK company based at Discovery Park, Kent, that has developed a production technology to deliver Omega 3 oils derived from a proprietary strain of freshwater algae. The Company established its first 10,000 litre production plant in late 2017 which marked the beginning of the Company's next phase, the commercialisation of Omega 3 production, enabling the Company to upscale production and target a number of key markets such as nutritional therapeutics, skin care, and other healthcare applications. This company is focused on developing, sourcing and deploying technology-based solutions to meet the growing demand for health-promoting ingredients from algae. AlgaeCytes uses its patented technology primarily to create, from sustainable proprietary algae sources, and sell high value vegetarian, premium ingredients/products to the healthcare, personal care and pharmaceutical product markets.

<http://algaeocytes.com/about-us/>



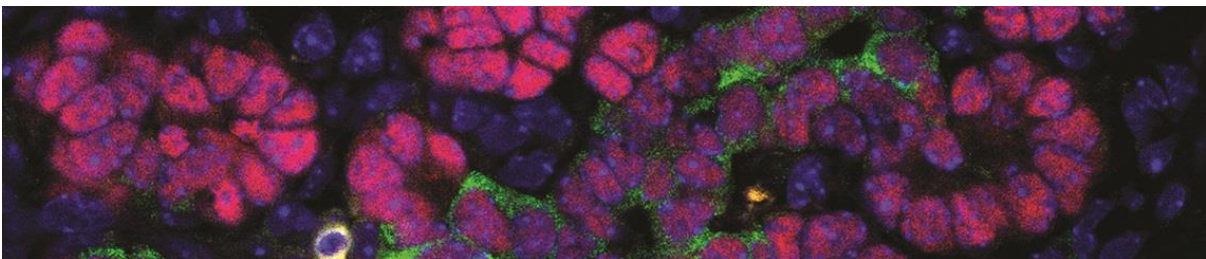
Varicon Aqua is the manufacturer of the Phyco-™ range of photobioreactors and the Cell-Hi line of algal nutrients. Based in the UK their team has more than 30 years' of experience in design, consulting, construction and deployment of algae photobioreactors and aquaculture production. They have deployed over 200 photobioreactor systems across the globe, ranging in scale from 5 L to 400,000 L. They provide both laboratory and industrial scale platforms for the cultivation of algae to a broad range of commercial and academic partners. They employ technicians, researchers, engineers and biologists who understand algal bioprocesses; from wastewater treatment to bulk and high value production. "This unique experience gives us a competitive advantage when working with clients, allowing us to specify bespoke photobioreactor systems for a wide range of applications. We pride ourselves on our ability to support our clients from inception through to commissioning and commercialisation."

<http://www.variconaqu.com/>



The Company of Biologists is a not for profit publishing organisation dedicated to supporting and inspiring the biological community. The Company publishes five specialist peer-reviewed journals: *Development*, *Journal of Cell Science*, *Journal of Experimental Biology*, *Disease Models & Mechanisms* and *Biology Open*. It offers further support to the biological community by facilitating scientific meetings and communities, providing travel grants for researchers and supporting research societies.

<https://www.biologists.com/>



CONFERENCE SUSTAINABILITY

Care has been taken to ensure that BPS 2020 is as sustainable as possible. From sourcing products with green credentials to ensuring that where possible the food and drink on offer is local.

Catering

University Commercial Services Plymouth provide local, sustainable and ethically sourced food. We choose to invest in our local South West producers and contribute to city wide initiatives to alleviate the lack of access of health food in the city by providing community access to our sustainable cafes and supporting small scale producers. We have been awarded the following accreditations:-

- Sustainable Restaurant Association Gold 3-star rating
- Green Gown Award, winning the Food and Drink category
- Are ISO14001 accredited
- 60% of all food and drink is sourced from South West suppliers

These accreditations have been achieved by ensuring:-

- We source from Plymouth markets, caught by crews attached to the Responsible Fisherman's scheme
- All eggs are free range
- All milk is locally sourced
- A combination of food composting and food bank donations have contributed to a reduction in food waste
- Removed single use plastic bottled water from Hospitality only providing glass bottles or tap water in jugs / glass bottles.
- No plastic straws in use across Hospitality or any catering outlets
- Refill Stations – tap water in the UK is perfectly drinkable and we would like to encourage you to refill your water bottles at the refill locations below.

