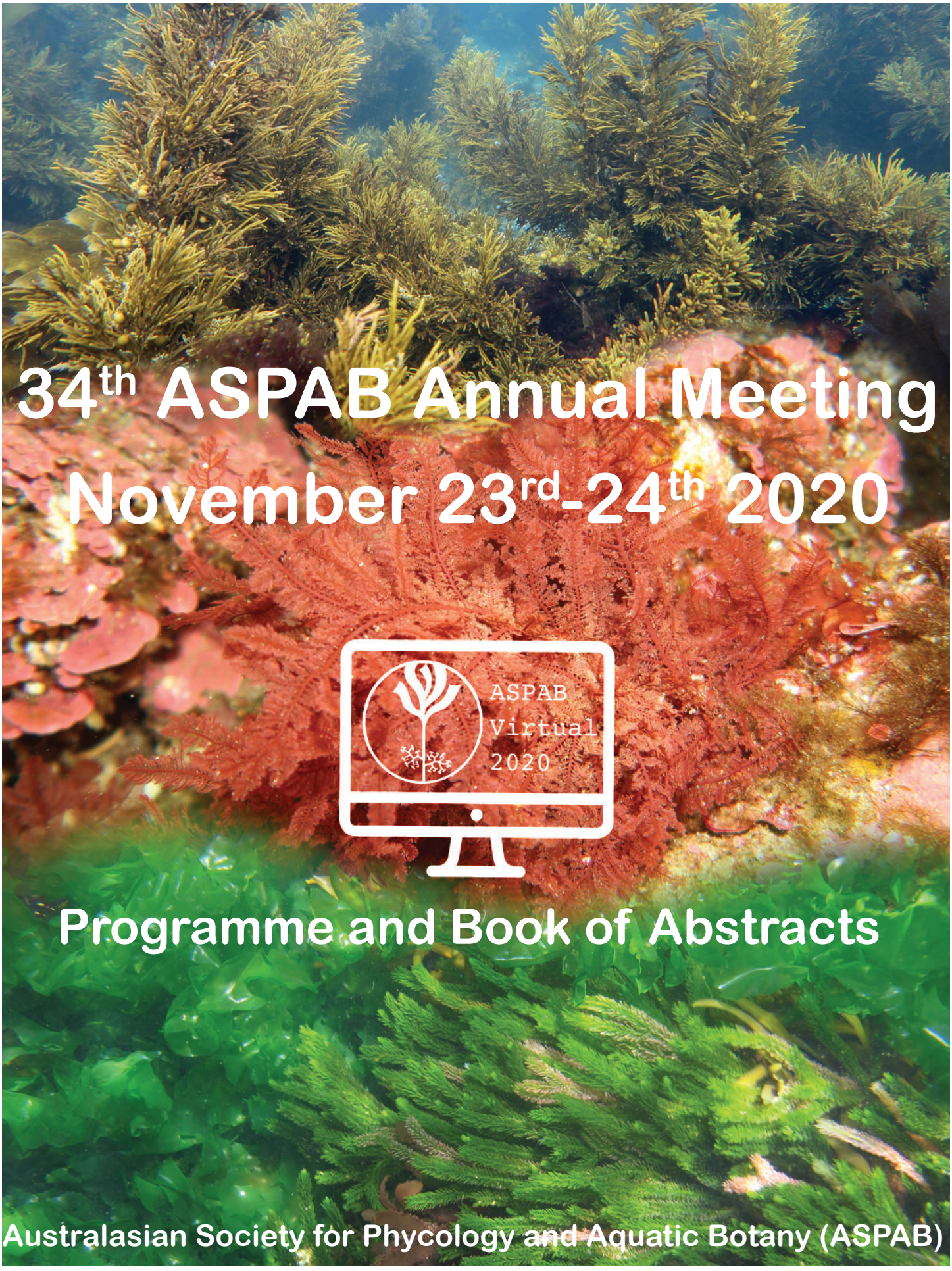

34th ASPAB Annual Meeting
November 23rd-24th 2020

ASPAB
Virtual
2020

Programme and Book of Abstracts

Australasian Society for Phycology and Aquatic Botany (ASPAB)

The 34th annual Australasian Society for Phycology and Aquatic Botany (ASPAB) meeting

@ First Online Conference

Programme

Monday November 23rd			
Chair	**Time**	**Speaker**	**Title**
ASPAB President Dr Alecia Bellgrove	13:00-13:10 NZDT	Dr Alecia Bellgrove	Welcome and Introductory Remarks
	13:10-13:40	**Plenary Talk:** Ass. Prof. Ceridwen Fraser	Drifting on shifting seas: what DNA can tell us about seaweed dispersal and evolution
	13:40-13:50	Break	
Dr Maren Preuss	13:50-13:57	Olivia Wynn ☆	RNA isolation from macroalgae: challenges and applications
	13:57-14:04	Trevor Bringloe	High-throughput sequencing of the kelp *Alaria* (Phaeophyceae) reveals epi-endobiotic associations, including a likely parasitic brown alga
	14:04-14:11	Shauna Murray	Using molecular genetic techniques to detect harmful algal bloom forming species impacting aquaculture
	14:11-14:18	Ellyn Erlania ☆	Contribution of seaweed to carbon sequestration

Chair	Time	Speaker	Title
Dr Maren Preuss	14:18-14:25	Namrata Chand ☆	Ecosystem functioning and role of soft-sediment red macroalgal communities in Otago harbour
	14:25-14:32	Albert Pessarrodona ☆	Contraction of habitat structure in temperate marine forests
	14:32-14:39	Simon Gartenstein ☆	Predator-prey dynamics in *Lessonia trabeculata* kelp forests of south-central Chile
Catia Jose Abreu De Freitas	14:39-14:49	Break	
	14:49-14:56	Allyson Eduardo Nardelli ☆	Reproduction and growth in natural populations of *Lessonia corrugata*
	14:56-15:03	Jakop Schwoerbel ☆	Effects of density on early life history stages of *Ecklonia radiata* and *Lessonia corrugata*
	15:03-15:10	Phil Novis	*Lindavia intermedia*: an invasive diatom causing “lake snow” in New Zealand
	15:10-15:17	Jacqui Pocklington	Adaptive management of the invasive kelp *Undaria pinnitifida* in Port Phillip Heads Marine National Park

Tuesday November 24th

Chair	Time	Speaker	Title
ASPAB President Dr Alecia Bellgrove	13:00-13:30 NZDT	**Plenary Talk:** Dr Stacey Trevathan-Tackett	Microbiomes in vegetated coastal eco-systems: from bioindicators to biogeo-chemistry
	13:30-13:40	Break	
Jakop Schwoerbel	13:40-13:47	Ellie Paine ☆	Implications of ocean acidification on the release of dissolved organic carbon by seaweeds with various carbon uptake mechanisms
	13:47-13:54	Aleluia Taise ☆	Effects of ocean acidification on *Caulerpa* species
	13:54-14:01	Erik Krieger ☆	Resistance of coralline algae to ocean warming and marine heatwaves
	14:01-14:08	Damon Britton	Adjustments in fatty acid composition is a mechanism that can explain resilience to marine heatwaves and future ocean conditions in the habitat-forming seaweed *Phyllospora comosa*
	14:08-14:15	Matthias Schmid	Essential fatty acids in the Future Ocean: Impact of climate change on production of essential fatty acids in various temperate macroalgae

Chair	Time	Speaker	Title
	14:15-14:22	Amirreza Zarekarizi ☆	Seasonal variation in fucoxanthin content of different species of brown seaweeds in Brighton Beach, New Zealand
	14:22-14:32	Break	
Ellie Paine	14:32-14:39	Zoë Brittain ☆	Seaweed, indigenous knowledge and the Blue Economy
	14:39-14:46	Elisabeth Strain	Optimizing the initial cultivation stages of kelp *Ecklonia radiata* for restoration
	14:46-14:53	Cecilia Biancacci	CRC-P Seaweed solutions for sustainable aquaculture
	14:53-15:00	Wouter Visch	Cultivating three kelp species (order Laminariales) in Tasmania: preliminary results
	15:00-15:07	Thiru Somasundaram ☆	Future-proofing Australian agriculture with seaweed supplementation
	15:07-15:14	Vanessa Skrzypczyk ☆	Elemental profiling of Australian seaweeds with commercial potential
	15:14-15:21	Hajar Shayesteh ☆	Fed batch mixotrophic approach to the co-production of phycocyanin and polyhydroxybutyrate from *Arthrospira platensis*
	15:21-15:28	Grace Edwards ☆	Does biodiversity enhance nutrient uptake rates across three Tasmanian seaweed species? and implications for IMTA
	15:28-15:35	Navid R. Moheimani	Algal culture to treat anaerobic digestate effluents
	15:35-15:45	Break	
ASPAB Secretary Prof. Joe Zuccarello	15:45-16:35	Annual General Meeting (AGM)	
ASPAB President Dr Alecia Bellgrove	16:35-16:45	Closing remarks and student prizes	

☆ Students

Abstracts (organized by presentation time):

Plenary Talk:
Drifting on shifting seas: what DNA can tell us about seaweed dispersal and evolution

Ass. Prof. Ceridwen Fraser*

**University of Otago, Department of Marine Science, Dunedin 9016, New Zealand*

ceridwen.fraser@otago.ac.nz

The Southern Hemisphere is largely oceanic, with many landmasses separated by hundreds or thousands of kilometres of water. Around the Southern Hemisphere, however, there are striking similarities in coastal communities – the same or closely related species are often found growing on far-distant shores. Scientists have long speculated that buoyant seaweeds might drift long distances at sea, potentially carrying diverse passengers such as non-buoyant seaweeds and invertebrates. Only relatively recently, however, with the development of genetic and genomic technologies, have we been able to demonstrate just how powerful a dispersal mechanism algal rafting can be. Indeed, genomic approaches can allow us to pinpoint precisely where a dispersing macroalgal raft originated from, and have revealed that drifting seaweeds can sometimes travel tens of thousands of kilometres. Somewhat surprisingly, however, dispersal does not always lead to population connectivity; instead, modelling indicates that in some cases major disturbances are needed before dispersing lineages can establish at new locations. Genetic approaches are also revealing greater diversity in seaweeds than we had previously been able to detect, with new cryptic or morphologically similar species being discovered / described through DNA analyses. Drawing on examples from the high latitudes of the Southern Hemisphere, this talk will highlight how genetic and genomic tools can provide powerful insights into the evolutionary and biogeographic processes shaping the diversity and distribution of seaweeds.

RNA isolation from macroalgae: challenges and applications

O. J. Wynn*, A.R. Bridle, C. L. Hurd

**Institute for Marine and Antarctic Studies, 20 Castray Esplanade, Battery Point, TAS 7004*

oowynn@utas.edu.au

Macroalgae are a diverse group of photosynthetic organisms within coastal regions and they are sensitive to ocean global change such as ocean acidification and warming. To understand how they will respond to ocean change requires molecular studies to identify the biomolecular mechanisms that underpin their physiological responses: isolation of high-quality nucleic acids is a prerequisite. RNA extractions are challenging as RNA is a labile molecule and is subject to degradation by enzymes. Furthermore, macroalgae are considered recalcitrant as RNA extractions are hindered by high concentrations of polysaccharides and secondary metabolites that are released upon cell lysis and can be co-extracted with the RNA. Current methods exist for extracting RNA, but they only work on very few species. In this presentation I will discuss the challenges with RNA extractions in macroalgae and present the results of experiments to compare our newly developed method to other methods: a commercial kit and the common CTAB method. I will discuss some of the applications of the new method to future work.

High-throughput sequencing of the kelp *Alaria* (Phaeophyceae) reveals epi-endobiotic associations, including a likely parasitic brown alga

T. T. Bringloe, R. Sauermann, D. Krause-Jensen, B. Olesen, A. Klimova, T. A. Klochkova, H. Verbruggen

**School of BioSciences, University of Melbourne, Parkville Campus, Victoria, Australia, 3010*

trevor.bringloe@unimelb.edu.au

Whole genome sequencing datasets present opportunity to not only study evolution in the target organism, but also the associated holobiont. The capacity to study epi-endobiotic kelp associations is therefore improving with the availability of high-throughput sequencing datasets. The goal of this study was to determine if shotgun sequencing libraries could be used to document epi- and endophyte/faunal species colonising *Alaria* kelp sporophytes from Kamchatka (Russia), the Bay of Fundy (Atlantic Canada), and Nuuk (Greenland). Mitochondrial *coxI* and plastid *rbcL* reads were extracted and assembled from six *Alaria* whole genome sequencing datasets. In total, contigs representing 11 epi-endobiotic species were assembled, of which Chordariacean diversity dominated. Given the presence of a highly novel Phaeophycean *coxI* sequence lacking an *rbcL* counterpart, we secondarily tested our hypothesis that the *coxI* sequence belonged to a parasitic brown alga. The entire read dataset was assembled for the host *Alaria* specimen, the mitochondrial genome of the putative parasite was retrieved, and plastid scaffolds were annotated then screened for genes matching the phylogenetic placement of the mitochondrial genome. The mitochondrial genome of the candidate parasite displayed atypical features, including duplicated genes and earrangements, supporting the notion this organism may have a deviant lifestyle.

rThe plastid genome lacked genes for photosystem and cytochrome complexes and chlorophyll biosynthesis, confirming our hypothesis that the novel Phaeophycean represented a parasitic species. Furthermore, membership at the ordinal level remained unclear for the parasitic brown alga. Our study showcases the utility of whole-genome sequencing datasets in revealing surprising aspects of kelp holobionts.

Using molecular genetic techniques to detect harmful algal bloom forming species impacting aquaculture

S. A. Murray*, P. A. Ajani, A. Verma, J. H. Kim, R. Ruvindy, K. McLennan

**University of Technology Sydney, School of Life Sciences*

Shauna.Murray@uts.edu.au

In Australia and internationally, marine harmful algal blooms (HABs) caused by certain species of dinoflagellates and diatoms have been increasing, leading to the uptake of toxins in seafood and deaths of marine life. Genetic and genomic tools allow insight into the genetics of toxicity and bloom development, and provide the potential to design new detection technologies, some of which can be rapidly conducted on site. In this talk, I will describe qPCR assays we have developed and tested to detect harmful algal toxins from multiple species of the dinoflagellates *Alexandrium* and *sxtA* (Paralytic Shellfish Toxins), *Prorocentrum minimum*, a common HAB-forming species associated with eutrophication, and the diatom *Pseudo-nitzschia cuspidata*, the most common source of Amnesic Shellfish Toxins in southern Australia. We have collected long term, weekly datasets of estuarine water using eDNA methods in certain oyster-aquaculture producing estuaries and mussel farms, and applied assays to detect certain HAB species. We compare results of qPCR quantification assays to information collected from other sources including light microscopy-based detection, toxin detection using LC-MS/MS and molecular barcoding, based on the detection of an rRNA gene.

Contribution of Seaweed to Carbon Sequestration

E. Erlania*, P. Macreadie, D. Francis, A. Miller, A. Bellgrove

**Deakin University, School of Life and Environmental Sciences, Centre for Integrative Ecology, Warrnambool Campus, Warrnambool, Victoria, Australia*

eerlania@deakin.edu.au

The incorporation of seaweed into Blue Carbon (BC) strategies has remained controversial as they grow on hard substrata and thus do not facilitate accretion of carbon (C) within their habitat. However, macroalgae may be significant C donors to carbon sink ecosystems due to

the ability to be transported. This project has been investigating the use of biomolecular (environmental DNA/eDNA) markers and fatty acids isotopes-based biomarkers to enable seaweed C discrimination and quantification in marine (coastal and oceanic) sediments. First, shotgun sequencing has been used to examine ancient deep-sea sediment cores from around Maria Island, Tasmania. This indicated the presence of seaweed C preserved in the deep ocean for thousand years. Second, amplicon-based sequencing has been used to look at the seaweed C buried in the coastal sediment cores around a riverine-marine transect along the Swan River to the coastline in Western Australia. The following part of this study is exploring the potential use of fatty acids coupled with associated C-isotope for discrimination of seaweed C from other sources in the sediment samples as well as for quantification. All of the data analyses are works in progress. It is expected that those biomarkers can detect and quantitatively estimate seaweed contributions to carbon sequestration in coastal and oceanic sediment and provide empirical evidence to include seaweed into the global BC assessment.

**This abstract is an overview of an ongoing PhD project*

Ecosystem functioning and role of soft-sediment red macroalgal communities in Southern New Zealand

N. Chand*, D. Pritchard, W. Nelson, R. D'Archino, C. Hepbrun

**PhD Candidate- University of Otago, Dunedin 9016, New Zealand*

namrata.chand@postgrad.otago.ac.nz

Around the globe, coastal environments such as harbours and bays are highly valuable due to the various ecosystem services they provide. Coastal environments of New Zealand host high macroalgal diversity. Within coastal areas, extensive algal meadows can be found on soft sediment habitats. These meadows contribute towards ecosystem services such as sediment stabilisation, food, habitat for various organisms, carbon burial, and biofiltration of nutrients in water column. Unfortunately, there is limited knowledge on shallow soft sediment macroalgae, with its role being under-recognized.

In Southern New Zealand, Otago Harbour, Stewart Island and Fiordland are known areas with large algal meadow occurrence. My PhD research investigates community habitat and nutrient ecophysiology of soft sediment red macroalgal communities in Otago Harbour, Stewart Island and Fiordland, with a focus on the red endemic macroalgae *Adamsiella Chauvinii*. Specifically the research investigates community composition, biomass and epifaunal structure within the algal beds, and the organic (urea) and inorganic (nitrate and ammonium) forms of nitrogen uptake by the endemic soft-sediment macroalgae *Adamsiella Chauvinii.*

This research provides new and valuable information on the nitrogen uptake ecophysiology of *Adamsiella Chauvinii* and the improved understanding of its community structure.

Contraction of habitat structure in temperate marine forests

A. Pessarrodona*, K. Filbee-Dexter, T. Alcoverro, J. Boada, C. J. Feehan, S. Fredriksen, S. P. Grace, Y. Nakamura, C. A. Narvaez, K. M. Norderhaug, T. Wernberg

**UWA Oceans Institute and School of Biological Sciences, University of Western Australia, Crawley, Western Australia 6009, Australia*

pessa3@gmail.com

Humans are rapidly transforming the habitat structure and configuration of the planet's ecosystems. Understanding the ecological and socioeconomical repercussions of these changes is however challenged by the diversity of drivers and species characterizing such shifts at local and regional scales. Here we show that the loss of forest-forming seaweeds and the rise of ground- covering 'turfs' across four continents consistently resulted in the simplification of underwater habitat structure, with seascapes converging towards flattened habitats that were structurally more homogenous and less complex than forests. Convergence occurred despite these seascapes consisting of vastly different species richness and seaweed groups providing architecture, as well as disparate drivers of forest loss. Turf-dominated seascapes were equally or more architecturally different than other habitats resulting from forest loss (like barrens created by herbivore overgrazing), suggesting that they operate in a structurally new space. This work demonstrates that the replacement of marine forests by turfs is a generalizable phenomenon that leads to a contraction of the diversity of habitat configurations encountered along temperate coastlines.

Predator-prey dynamics in *Lessonia trabeculata* kelp forests of South-central Chile

S. Gartenstein*, N. Valdivia, A. Pérez-Matus, N. Godoy, F. Torres

** Programa de Doctorado en Biología Marina, Facultad de Ciencias, Universidad Austral de Chile, Valdivia, Chile*

simon.gartenstein@alumnos.uach.cl

Kelp forests support biodiverse food webs which may be sustained by predator-prey dynamics. This study investigated the abundance patterns and stomach contents of the carnivorous predatory fish, *Prolatilus jugularis*, in the relatively unexplored subtidal kelp forests of *Lessonia trabeculata*, south-central Chile, between October 2019 and March 2020. Sampling of fish and benthic invertebrates (potential prey availability) was done by scuba along transects in a semi-protected kelp forest at a single location. The diet of *P. jugularis* was comprised mostly of crustaceans but also molluscs and polychaetes, and these were related to the prey resources in the kelp forest. The Amphipoda were the most abundant prey type in the kelp forest and diet, indicating that this trophic resource is probably not limiting, and was most likely consumed opportunistically. In accordance with Ivlev's selectivity index, the Decapoda, Isopoda and Ostracoda were the most favoured prey selected.

The principal prey types (especially crustaceans) are high energy food resources and maybe important nutritionally to *P. jugularis*. This study presented new data and showed that the feeding grounds in the kelp forests are relatively biodiverse and resource rich. Due to existing knowledge gaps, further investigation of food web function in kelp forests e.g. predator-prey dynamics, will be imperative for future ecosystem management and conservation of marine resources in the region.

Reproduction and growth in natural populations of *Lessonia corrugata*

A. E. Nardelli*, W. Visch, G. Farrington, C. Sanderson, A. Bellgrove, J. Wright, C. L. Hurd

**Institute for Marine and Antarctic Studies (IMAS), 20 Castray Esplanade, Battery Point, 7004, TAS, Australia*

Allysoneduardo.nardell@utas.edu.au

Kelp beds (Order Laminariales) are one of the most diverse and productive ecosystems in coastal temperate regions, supporting a coastal ecosystems through primary production and uptake of dissolved nutrients. How effective these processes are depends on the kelps' growth rate, reproduction, and recruitment patterns. In turn, these processes can vary temporally and spatially due to the variation of nutrients, light, temperature, and wave exposure. *Lessonia corrugata* (Lucas 1931) is an endemic species of Tasmania, Australia, with a wide distribution around the state. It is found in shallow subtidal rocky shorelines, with a preference for places with moderate to high exposure to wave action. Despite its ecosystem dominance, we know nothing of the fundamental seasonal characteristics of *L. corrugata*. This work aims to understand the spatiotemporal patterns of *L. corrugata* in reproduction and development. Three randomly chosen sites on the southeast coast of Tasmania (Taroona, South Arm, and Coal Point) will be used in this study. An area (20 m^2) will be marked at each of the sites, and density and recruitment will be noted. In addition, growth rates, loss of tissue, morphology, fertile tissue maturation stages, the spore viability, biofouling, environmental parameters (i.e. nutrients, waves), and tissue biochemistry will be measured at two month invervals. This research is of fundamental importance to ensure the preservation of natural *L. corrugata* populations, and cultivation of this endemic species in Tasmania.

Effects of density on early life history stages of *Ecklonia radiata* and *Lessonia corrugata*

J. Schwoerbel*, W. Visch, J. Wright, A. Bellgove, C. J. Sanderson, C. L. Hurd

*Institute for Marine and Antarctic Studies (IMAS), 20 Castray Esplanade, Battery Point, Tasmania, 7004, Australia

Jakop.Schwoerbel@utas.edu.au

Despite their widespread distribution and status as keystone species, the biology of many kelp species, particularly their early life stages, remain poorly understood. Detailed knowledge of the microscopic phases is, however, of vital importance to optimise seaweed aquaculture and conservation. This study assesses the impact of six settlement densities (10-320 individuals mm^{-2}) on germination, growth and fertilisation of *Ecklonia radiata* and *Lessonia corrugata*. Germination was unaffected by density in both species with ~65% of *E. radiata* and ~50 of *L. corrugata* spores germinating. Sex ratio of ~0.5 was also not different among treatments of either species. Female *E. radiata* gametophytes were larger (by area) at 40 ind mm^{-2}, whereas males were larger at treatments of ≤40 individuals mm^{-2}. Lower density treatments (<40 ind mm^{-2}) in general yielded substantially more sporophytes than high density treatments. Based on these results, low densities are recommended for fast and efficient sourcing of juvenile sporophytes, keeping in mind that the experiment did not consider factors such as water motion that might affect the results. These results will inform future experiments on the physiology of early life history stages of these species and ultimately optimise the nursery phase of seaweed aquaculture operations.

Lindavia intermedia: an invasive diatom causing "lake snow" in New Zealand

P. Novis*, M. Schallenberg, K. Gordon, C. Kilroy, T. Bell, S. Hinkley, É. Saulnier-Talbot

*Manaaki Whenua-Landcare Research

novisp@landcareresearch.co.nz

The diatom *Lindavia intermedia* causes nuisance pelagic mucilage, known as "lake snow", in pristine New Zealand lakes. This species arrived in recent decades and spread rapidly, with many lakes developing temporary or seasonally persistent lake snow episodes. Lake snow degrades the values associated with pristine lakes through biofouling, including by coating fishing lines, adhering to swimmers, and blocking domestic and municipal water filters. This fouling imposes significant costs to some local councils.

Although manifesting in lakes, *Lindavia intermeda* displays similarities to the riverine *Didymosphenia geminata* by generating large amounts of extracellular biomass, favouring clean water systems, and being thought to have arrived from North America. Unlike "didymo", however, the problems associated with *L. intermedia* are almost entirely restricted to New Zealand, and particularly the South Island.

We will describe some tools developed to study this species and its effects, and briefly

address the following areas:

1) Timing of the incursion, through analysis of lake sediment cores.
2) Current distribution in New Zealand and Washington State, USA, and which lakes seem most susceptible.
3) Hypotheses regarding the trigger for lake snow production.

Lindavia intermedia and associated issues have been most prominent in the lakes of Central Otago. However, it continues to spread in New Zealand, shown by recent first detections in Westland and in the large pristine Nelson Lakes. The development of a substantial population in the Nelson City water supply reservoir may prove to have significant consequences for local infrastructure. Possible solutions currently appear limited, but prospects will be discussed.

Adaptive management of the invasive kelp *Undaria pinnitifida* in Port Phillip Heads Marine National Park.

J. Pocklington*, J. Wheeler, N. Filby, E. Westlake

**Parks Victoria*

jacqui.pocklington@parks.vic.gov.au

The invasive kelp *Undaria pinnatifida* was first detected at 10-11m depth on the reef of Pope's Eye (Port Phillip Heads Marine National Park) in Victoria in 2016. Despite initial hand-pulling removal efforts which removed 1.9 tonne wet weight, the population remained abundant in late 2018. New removal methods isolating the sporophyll, and a renewed control and monitoring program diving every 1-2 months was then implemented. Although less abundant during the warmer months following its seasonal growth cycle, *Undaria* sporophytes remain present at Pope's Eye year-round. In the first 12 months of the new program, an 82% reduction of *Undaria* occurred and a critical removal period was identified. The renewed methods have led to a successful reduction in population, as well as improved manual handling and efficiencies.

Plenary talk:

Microbiomes in vegetated coastal ecosystems: from bioindicators to biogeochemistry

Dr Stacey Trevathan-Tackett*

**Deakin University, School of Life & Env. Sciences, Melbourne, Burwood VIC 3125*

s.trevathantackett@deakin.edu.au

As marine botanists and phycologists, we well know that health and resilience of these photosynthetic organisms and the ecosystems they build depend on a fine balance among physical, chemical and biological conditions. In recent years, we have increased our understanding the importance of microorganisms – or the microbiome – to the health of marine and coastal macrophytes. Members of the microbiome can provide both benefits to the host and ecosystem function, such as sulphide detoxification and nutrient cycling. They can also be detrimental, as in the case of pathogens and parasites. This talk will highlight the recent advances in microbial ecology for coastal plants, particularly seagrass-associated microbiomes. We will also explore the pressing research questions and exciting prospects for the field going forward.

Implications of ocean acidification on the release of dissolved organic carbon by seaweeds with various carbon uptake mechanisms

E. R. Paine*, D. Britton, M. Schmid, P. W. Boyd, G. Diaz-Pulido, C. L. Hurd

**Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, 7000*

Ellie.paine@utas.edu.au

Concentrations of dissolved carbon dioxide (CO_2) in the ocean are predicted to increase by 200% by the year 2100 due to anthropogenic activity, causing ocean acidification (Hurd et al., 2018). The response of seaweeds to increased CO_2 is difficult to predict but thought to depend on whether they are currently limited by dissolved inorganic carbon (DIC) and the mechanism by which they take up DIC. In natural seawater, DIC is primarily available as bicarbonate which cannot pass through the seaweed plasmalemma via diffusion; 65% of seaweeds possess mechanisms which aid its uptake, termed CO_2 concentrating mechanisms (CCMs) (Raven, 1991). However, 35% of seaweeds do not possess CCMs and solely use CO_2 as their source of DIC (non-CCM species). As DIC levels increase in the ocean, seaweeds which are currently limited for DIC may utilise this additional carbon for growth. Once DIC is assimilated into organic carbon via photosynthesis, seaweeds may release dissolved organic carbon (DOC) into the surrounding seawater depending on local environmental conditions such as light and nitrogen. Diaz-Pulido et al. (2020) found a

greater DOC release with an increase in seawater DIC i.e. increasing ocean acidification. We designed an experiment to test the effect of ocean acidification on DOC release by three temperate seaweed species with differing DIC uptake mechanisms: *Hemineura frondosa* (Rhodophyta, non-CCM), *Lenormandia marginata* (Rhodophyta, CCM) and *Ecklonia radiata* (Ochrophyta, CCM). I will discuss the background for this experiment and the experimental design involved.

Effects of ocean acidification on Caulerpa species

A. Taise*, E. Krieger, G. C. Zuccarello, C. E. Cornwall,

**School of Biological Sciences, Victoria University of Wellington*

aleluia.taise@vuw.ac.nz

Caulerpa is one of the rare few genera that have species both with and without CO2 concentrating mechanisms (CCMs) that allow active uptake of HCO3-. It has been suggested that different species of Caulerpa may respond differently to ocean acidification (OA) because of their divergent dissolved inorganic carbon (DIC) uptake. For example, species without CCMs are more likely to benefit from OA, due to currently being DIC limited. Two of the most common Caulerpa species in New Zealand, *C. brownii* and *C. geminata* could have vastly different responses to OA. *C. brownii* does not have a CCM while *C. geminata* possesses a CCM. We investigated the effects of OA on growth, photo-physiology and DIC utilization by C. brownii and *C. geminata* in a manipulative laboratory experiment. The two species were exposed to four mean seawater pH treatments (8.03, 7.93, 7.83 and 7.63). In all cases, mean and variability in growth rates of *C. brownii* increased under OA scenarios, while growth rates for *C. geminata* declined under OA treatments. This is concordant with predictions that non-CCM species will be capable of utilising additional CO2, while species with a CCM cannot utilize addition CO2, while at the same time demonstrating that DIC use alone does not predict responses to OA. We show divergent responses of two Caulerpa species that could have implications for their future abundance and roles in Australasia. However, further research is required to ascertain whether these trends will persist under concurrent ocean warming.

Resistance of coralline algae to ocean warming and marine heatwaves

E. C. Krieger*, A. Taise, J. D. Gaitán-Espitia, E. Le Ru, P. W. Dillingham, S. K. Davy, W. A. Nelson, C. E. Cornwall

*School of Biological Sciences, Victoria University of Wellington, Victoria University of Wellington Wellington 6012, New Zealand

erik.krieger@vuw.ac.nz

Anthropogenic greenhouse gas forcing is heating up the world's oceans. Accompanied by this long- term rise of average sea surface temperatures (ocean warming) is the increase in frequency and intensity of extreme short-term temperature events (marine heatwave). Heatwaves and ocean warming have both been identified as a main threat to marine ecosystems. However, research on the impacts of ocean warming and marine heatwaves on foundational species in temperate oceans is lacking. To this end, a manipulative laboratory experiment was conducted exploring the physiological, geochemical, and transcriptional responses of four temperate coralline algal species to ocean warming and marine heatwaves. Thus, all coralline specimens were exposed to either present day (16°C) or future summer temperatures (18.8°C) for fourteen days. A two-week long marine heatwave was simulated for half of the specimens of both mean temperatures after this temperature acclimation. Temperatures increased during the first week of the heatwave until peak temperatures were reached (16+2.8°C and 18.8+2.8°C). During the second week temperatures were gradually decreased to pre-heatwave conditions. A two-week recovery period followed. Unexpectedly, none of the species showed signs of detrimental impacts caused by either long- or short-term exposure to higher water temperatures across a large range of response metrics measured. This indicates either the lack of thermal sensitivity of examined parameters or the ability to buffer detectable phenotypic changes at the molecular level. The results suggest that temperate coralline algae may be more robust to marine heatwaves than other important foundations species, such as kelps and corals.

Adjustments in fatty acid composition is a mechanism that can explain resilience to marine heatwaves and future ocean conditions in the habitat-forming seaweed *Phyllospora comosa*

D. Britton*, M.Schmid, F.Noisette, J. N. Havenhand, E. R. Paine, C. M. McGraw, A. T. Revill, P. Virtue, P. D. Nichols, C. N. Mundy, C. L. Hurd.

*Institute for Marine and Antarctic Studies, University of Tasmania, 20 Castray Esplanade

Damon.Britton@utas.edu.au

Marine heatwaves are extreme events that can have substantial and lasting impacts on marine species. Seaweeds have been observed to be highly susceptible to marine heatwaves in the field, but the physiological drivers of this susceptibility are poorly understood. Additionally, there is little knowledge on the effects of marine heatwaves in conjunction with ocean

warming and acidification. We conducted a laboratory culture experiment in which we tested the growth and physiological responses of the seaweed *Phyllospora comosa* to marine heatwaves, ocean warming and acidification. Heatwaves were superimposed on current and future ocean conditions and responses were tested both during the heatwaves, and after a seven-day recovery period. Heatwaves reduced net photosynthetic rates in both current and future conditions, while respiration rates were elevated under heatwaves in the current conditions only. Following the recovery period, there was little evidence of heatwaves having lasting negative effects on growth, photosynthesis, or respiration. Exposure to heatwaves or future ocean conditions caused an increase in the degree of saturation of fatty acids. This adjustment may have counteracted negative effects of elevated temperatures by decreasing membrane fluidity. Furthermore, *P. comosa* appeared to down-regulate the energetically expensive carbon-concentrating mechanism (CCM) in the future conditions. Energetic savings from this down-regulation was not invested in growth and was likely invested in the adjustment of fatty acid composition. This adjustment is a mechanism by which *P. comosa* and other seaweeds may tolerate the negative effects of ocean warming and marine heatwaves through benefits arising from ocean acidification.

Essential fatty acids in the Future Ocean: Impact of climate change on production of essential fatty acids in various temperate macroalgae

M. Schmid*, D. Britton, E. Paine, F. Noisette, V. Patti, R. Andy, N. Peter, C. L. Hurd

* *Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Tas, Australia*

matthias.schmid@utas.edu.au

Marine food webs, which include many economically and ecologically important species, ultimately depend on energy generated by primary producers such as seaweeds. Seaweeds are particularly important as they contribute omega-3 and omega-6 polyunsaturated fatty acids (PUFA), in particular the long-chain (≥C20) PUFA (LC-PUFA), to the coastal food web, which play essential physiological roles both in the algae themselves and in animals that consume them. The environmental conditions strongly impact the concentrations and composition of fatty acids in seaweeds. The expected climatic changes including increased temperature and levels of dissolved CO_2 in the future ocean are projected to lead to a decline in essential LC-PUFA in seaweeds with flow-on effects to higher trophic levels. The presented project investigated the impacts of ocean warming and ocean acidification on production of the key LC-PUFA in eight temperate seaweeds (four Rhodophyta and four Phaeophyceae). Results show that there was small impact on the fatty acid composition of single individuals. However, results indicate that there could be a shift in available fatty acids due to changes in the overall species composition, as a result of climate change.

Seasonal variation in fucoxanthin content of different species of brown seaweeds in Brighton beach, New Zealand

A. Zarekarizi*, L. Hoffmann, D. Burritt, R. D. Frew

**Department of Botany, University of Otago, Dunedin, New Zealand*

zaram365@student.otago.ac.nz

Seaweeds have generated enormous attention in the pharmaceutical industry as a source of bioactive compounds for the development of new drugs and healthy foods. Fucoxanthin (Fx) is one of the main marine carotenoids in brown seaweeds and has attracted the attention of nutraceutical, cosmetic, and pharmacological industries due to potential benefits for human health. Thus, identifying suitable sources of this compound is important for future production and commercialization. Moreover, understanding how environmental conditions influence the amount of Fx will provide important insights into how seaweed responds to a changing environment. In this study, the Fx content of nine different species of brown seaweed was investigated. The samples were collected from Brighton Beach, Otago, New Zealand in January, March, June, and September of 2020. Fx was initially extracted from freeze-dried samples by ethanol and then further purified by silica gel column chromatography. The result of HPLC measurements showed significant differences in Fx content between seaweed species and season. In most species, Fx contents increased in June and reached the maximum in September. During this period, light intensity and temperature were the lowest which leads to increased production of Fx through the xanthophyll-cycle pathway. Higher contents of Fx in *Cystophora* sp. and *Scytothamnus australis* indicate the potential of these seaweed species as a commercial source of Fx. The strong correlation of Fx content and seasonal variation confirmed that the best time for harvesting of seaweed with the highest amount of Fx is the period between winter and spring.

Seaweed, indigenous knowledge and the Blue Economy

Z. Brittain*, D. S. Jones, P. F. Francis, R. H. Thurstan, A. Bellgrove

** Deakin University, School of Life and Environmental Sciences, Centre for Integrative Ecology, Warrnambool Campus, PO Box 423, Warrnambool, Victoria 3280, Australia*

zebritta@deakin.edu.au

The Blue Economy is an emerging concept that relates to resources that can be found in marine and coastal environments. This more 'holistic' approach to ocean resource management is advocated as an effective way to tackle anthropogenic pressures currently damaging ocean systems, such as overfishing, pollution and climate change, whilst simultaneously improving economic and social outcomes. Despite the term gaining widespread use, there remains contention around exact definitions and goals of the concept, with different actors often expressing conflicting and contradictory understandings. This has led to a number of criticisms, notably the inability of the Blue Economy to appropriately include the perspectives and values of certain social and cultural groups, such as Indigenous peoples. As part of the 'Blue Economy', seaweed and its related industries in particular are

gaining growing attention, especially in Australia and Aotearoa New Zealand. In my PhD, I will be exploring the developing seaweed industry as a case study for wider dsicussions of Blue Economy and its ability to appropriately include Aboriginal and Maori perspectives.

Optimizing the initial cultivation stages of kelp *Ecklonia radiata* for restoration

S. Suebsanguan, E. M. A. Strain*, R. L. Morris1, S. E. Swearer

**Institute for Marine and Antarctic Science/University of Tasmania*

elisabeth.strain@utas.edu.au

Restoration of kelp forests typically relies on transplanting sporophylls to new locations and has limited application in regions with low remnant kelp cover. Cultivated of juvenile kelps requires fewer sporophylls and is a potential alternative and sustainable source of transplants for large-scale restoration projects. As cultivation still depends on the use of naturally sourced fertile sporophylls as 'seed' stock, optimizing cultivation methods is important to minimize this dependency on wild stocks. As a first step in optimizing cultivation methods for restoring beds of the laminarian kelp *Ecklonia radiata*, we tested the effects of sporophyll transport, storage, and dehydration on zoospore release; inoculum storage temperature on zoospore abundance, and media sterilization and inoculum concentration on zoospore settlement and resulting gametophyte densities. Our results show, to maximize zoospore release, sporophylls should be transported dry and inoculated within three hours. Inoculum can be stored at 4°C without affecting zoospore abundance and should be added to sterilized media at lower concentrations to reduce settled zoospore density and improve post-settlement survival of the gametophyte stage. This study provides practical recommendations for optimizing the initial cultivation procedures of *E. radiata*. To develop a full life-cycle cultivation protocol for kelp restoration purposes, future research should focus on optimizing sporophyte production, out-planting and transplanting techniques.

CRC-P Seaweed Solutions for Sustainable Aquaculture

C. Biancacci*, W. Visch, G. Farrington, B. Evans, P. Lamb, C.J. Sanderson, A. Bellgrove, K. Alexander, C. L. Hurd, C. Macleod

**Deakin University, School of Life and Environmental Sciences, Warrnambool, Victoria 3280, Australia*

c.biancacci@deakin.edu.au

The global demand for seaweed is increasing and more and more investors are looking at seaweed aquaculture as a sustainable and high-value new economic opportunity. In south-eastern Tasmania, research is underway to cultivate three Australian native kelps, *M. pyrifera*, *L. corrugata* and *E. radiata*, in an Integrated Multitrophic Aquaculture (IMTA)

system with salmon and mussels. The project *"CRC-P Seaweed Solutions for Sustainable Aquaculture"* is a collaboration between industry (Tassal Group Ltd and Spring Bay Seafoods) and research partners (University of Tasmania and Deakin University), that aims to define a viable seaweed culture model and from this develop an IMTA partnership model that brings together salmon, shellfish, and seaweed production to optimise regional economic, environmental, and societal benefits. The project is divided into three Working Packages (WP) that focus on 1) unlocking the seaweed potential, 2) developing farming technology and 3) assessing the sustainability of the IMTA model proposed. These WPs will provide viable seaweed culture options for Southern Australian and Tasmania, understanding the nutrient uptake potential of the selected species and identifying the best species, growing techniques, products and management structures for a successful and scalable seaweed aquaculture and IMTA. This will lead to identifying or developing further commercial applications and markets of valuable seaweeds in multiple sectors (e.g. food, feed, agriculture, and nutraceutical) that will guide the development of a profitable Australian seaweed industry, expected to reach a value of $1.5 billion by 2040.

Cultivating three kelp species (order Laminariales) in Tasmania: preliminary results

W. Visch*, C. Biancacci, G. Farrington, B. Evans, P. Lamb, C.J. Sanderson, A. Bellgrove, K. Alexander, C. L. Hurd, C. Macleod

*Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Tasmania, Australia

wouter.visch@utas.edu.au

Seaweed cultivation is gaining increased interest world-wide for both food and non-food applications. Currently, the global seaweed aquaculture sector produces over 30 million tonnes, but is primarily dominated by two Asian countries, namely China (47.9 %) and Indonesia (38.7 %). In order to meet future demands, seaweed aquaculture has to expand further beyond Asia into other regions with high production potential, such as Tasmania, an island state in southern Australia. The *"CRC-P Seaweed Solutions for Sustainable Aquaculture"* project aims to bridge this gap. Three native Laminarian kelps have been selected for aquaculture trials: *Macrocystis pyrifera*, *Ecklonia radiata*, and *Lessonia corrugata* which is also endemic to Tasmania. During this presentation I will present (i) preliminary results from our first culture season, (ii) discuss the challenges and (iii) give an overview of what is next.

Future-proofing Australian agriculture with seaweed supplementation

T. Somasandaram*, D. L. Callahan, D. S. Francis, A. Bellgrove

**Deakin University, School of Life and Environmental Sciences, Centre for Integrative Ecology, Warrnambool Campus, Warrnambool, Victoria, Australia*

tsomasundaram@deakin.edu.au

The environmental impacts of agriculture, particularly of intensive dairy farming are pernicious. Innovation in feeding strategies towards greater sustainability has recognised the potential to mitigate these impacts. Australian dairy farms are potential seaweed end-users as they have committed to reduce environmental impacts by various means including adopting sustainable feed materials. In this context, seaweeds are an attractive alternative dairy feed supplement. In my research sustainably produced seaweeds are hypothesised as potential dairy feed supplements to reduce methane emission while improving milk production, milk quality, and animal health. We will test the efficacy of seaweed supplementation in dairy feeds, through assessing the feeding quality of seaweeds based on their biochemical profile, and palatability; effects on cows' health, milk yield and quality, and enteric methane emissions. In this presentation I will present an overview of my PhD project.

Elemental profiling of Australian seaweeds with commercial potential

V. M. Skrzypczyk*, D. L. Callahan, D, S. Francis, A, Bellgrove.

**Deakin University, School of Life and Environmental Sciences, Centre for Integrative Ecology, Warrnambool Campus, Warrnambool, Victoria, Australia*

vskrzypc@deakin.edu.au

By the year 2030 aquatic farming is predicted to provide 93 MT of the world's seafood supply, with aquatic plant farming being the only aquaculture practice that does not contribute to the widespread nutrification of coastal waters. Interest in the potential to both farm and wild-harvest seaweeds in Australia is rapidly increasing. Seaweeds are proven rich sources of dietary trace minerals and essential elements that are often not found in traditional edible plant foods. However, due to the high affinity for mineral and contaminant accumulation by seaweeds, it is important to conduct in depth studies specifically on Australian seaweeds that have edible potential and can be sustainably farmed or wild harvested. This study screened for the presence of 70 elements in 6 Australian fucoid and laminarian brown seaweeds with commercial potential and of these, 50 were quantified. Replicate samples of each species were collected from 3 Victorian sites and processed consistent with methods for human consumption. Dried and ground samples were analysed by ICP-MS and dietary mineral composition was compared amongst species whilst accounting for spatial variation. Results are discussed in the context of health benefits of consuming the species studied. Further work will assess the potential for heavy metal contamination in this suite of species.

Fed batch mixotrophic approach to the co-production of phycocyanin and polyhydroxybutyrate from *Arthrospira platensis*

H. Shayesteh*, D. W. Laird, L. J. Hughes, M. A. Nematollahi, A. M. Kakhki, N. R. Moheimani

*Department of Biotechnology and Plant Breeding, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad, Iran

hajar.shayesteh@murdoch.edu.au

There is an increasing market to develop sustainable technologies for production of safe and environmentally friendly products such as bioplastics and pigments. Microalgae have bioremediation potential, enabling them to consume waste organic carbons through mixotrophic cultivation and produce multiple high-value chemicals. The co-production of two high value microalgal products, phycocyanin and polyhydroxybutyrate, in non-axenic *Arthrospira platensis* MUR126 cultures was investigated under fed-batch mixotrophic conditions using organic carbon supplements (acetate (A), oxalate (O), glycerol (G) and their combinations). Highest biomass growth was achieved where acetate alone was supplied followed by G + O + A > G + O > O > photoautotroph. The glycerol supplemented culture recorded a decrease in biomass after day 4 which was starkly reflected in the chlorophyll data due to substantial bacterial contamination. A decrease in chlorophyll was noted for all other mixotrophic conditions, a finding inconsistent with increasing biomass but indicative of less severe bacterial contamination. Mixotrophic feeds containing oxalate had the least bacterial contamination. Both PHB and phycocyanin were produced with a clear correlation between PHB content and the amount of bacterial contamination present in the mixotrophic cultures. Phycocyanin content increased in all mixotrophic cultures (except glycerol) with the highest content in the acetate fed culture. The extensive bacterial contamination encountered suggests that organic carbon addition needs fine control in order to improve the viability of non-axenic microalgal cultures.

Does biodiversity enhance nutrient uptake rates across three Tasmanian seaweed species? and implications for IMTA

G. Edwards*

*Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Tas., Australia

gracee@utas.edu.au

Seaweeds offer a wide range of uses including human food, animal feeds, biopolymers, pharmaceuticals, cosmetics and bioenergy compounds, making them of interest to both study and cultivate for human use. Light and the availability of nutrients in surrounding seawater both regulate seaweed growth. Seaweeds use nitrogen for growth and nitrogen containing compounds are known to be of metabolic importance to their cellular functioning. Ammonium is often taken up faster and in preference to nitrate. Organisms differ in their impacts on biogeochemical processes, therefore, there is some consensus that diversity can impact an ecosystem's functional capacity. Using different combinations of seaweeds from Chlorophyta, Rhodophyta and Ochrophyta lineages, this study sought to derive rates of differential nitrogen extraction between polycultures versus monocultures.

By combining all possible arrangements of the following Tasmanian seaweed species: *Asparagopsis armata*, *Chaetomorpha coliformis* and *Lessonia corrugata*, this study found a net release of nitrate in treatments containing *A. armata*. This trend may be explained as a stress response or relate to the energetic requirements of seaweeds when preferentially utilizing the different forms of nitrogen available in seawater. Finding a combination of seaweed species with a more efficient nitrogen uptake rate is beneficial to IMTA as it can help to offset the negative impacts associated with increased nitrogen inputs into water bodies. During this presentation I will discuss (i) which combinations of species had the most efficient nitrogen uptake potential (ii) how biodiversity may lend to an enhanced rate of nitrogen uptake and (iii) how this can be applied to IMTA in Tasmania.

Algal culture to treat anaerobic digestate effluents

N. R. Moheimani*

*Algae R&D Centre, Murdoch University, Murdoch, WA, 6150, Australia

n.moheimanj@murdoch.edu.au

The successful cultivation of algae on anaerobically treated wastewaters would not only allow for the bioremediation of the waste stream but also the cost effective production of algal biomass. The growth and bioremediation ability of a microalgal consortium of *Chlorella* sp. and *Scenedesmus* sp. for treating undiluted anaerobically digested piggery effluent (ADPE) was assessed. Growth and nutrient removal rates of algal consortium in raceway and inclined ponds as well as closed tubular photobioreactors were assessed. Paddle wheel driven raceway ponds were found to be most suitable cultivation system for long term porcess with nutrient removal rate at 25.9±8.6 mg NH^{4+}-N.$L^{-1}d^{-1}$. We also evaluated the nutritional value, pathogen load, in vitro digestibility and potential physiological energy (PPE) of ADPE-grown microalgae as a potential feedstock for pigs. Pathogen load of ADPE-grown microalgae was within regulatory limits. Crude protein of ADPE-grown microalgae was higher than full fat soybeans but was much lower than conventional soybean meals (SBM) currently employed as a source of protein in pig feeds. The essential amino acid content of the microalgae was also lower than SBM. Fatty acid composition of the microalgae was favourable with an omega-3:omega 6 ratio of ~1.9, which may offer potential for value-adding use in some diets.

Acknowledgments

We would like to acknowledge the planning of the 34th ASPAB meeting by the following members of the conference planning committee:

- Alecia Bellgrove (Deakin University, Australia)
- Cecilia Biancacci (Deakin University, Australia)
- Zoë Brittain (Deakin University, Australia)
- Gaby Keeler-May (University of Otago, New Zealand)
- Ellie Paine (UTAS, Australia)
- Maren Preuss (Victoria University of Wellington, New Zealand)
- Jakop Schwoerbel (UTAS, Australia)
- Joe Zuccarello (Victoria University of Wellington, New Zealand)

We would like to thank Roberta D'Archino NIWA, New Zealand) and Chris Cornwall (Victoria University of Wellington, New Zealand) for providing all photos used to create the conference program.


Thank you for attending
the 34th ASPAB conference
We look forward to seeing you next year!
Australasian Society for Phycology and Aquatic Botany (ASPAB)