24TH INTERNATIONAL SEAWEED SYMPOSIUM

19-24 FEBRUARY 2023

HOBART • TASMANIA • AUSTRALIA • ONLINE

SYMPOSIUM HANDBOOK

Welcome from ISA

As President of the International Seaweed Association, it is my great honor to welcome you to the twenty-four International Seaweed Symposium. Our beginnings date back to 1952 with the First International Seaweed Symposium held in Edinburgh, Scotland. To this day, the International Seaweed Symposium is a benchmark in academia-industry cooperation in the world of seaweeds. That is why we are pleased to welcome you to this symposium, both to the on-site and virtual participants who registered for this event. It has been an additional year to the original plan to hold the 24th International Seaweed Symposium, which we decided to postpone in order to achieve a greater participation of those interested in the world of seaweed, understanding that contact and physical presence allows us to achieve close ties between participants, scientists who share their findings and knowledge and where companies find the breeding ground for doing business.

This is the first time that our event takes place in Oceania, Hobart is the home of the southernmost state of Australia, a wonderful place where we will not only find a growing algae industry, but also strong and pioneering research groups devoted to the scientific knowledge of seaweed. I thank the Local Organizing Committee for the effort and enthusiasm they have put into the organization and success of this symposium. "Seaweeds in a changing world" is the theme of this symposium, we all have witnessed rising seawater temperatures, coastal eutrophication, an increase in infectious diseases, and pest outbreaks that alone or combined have had effects on seaweed biodiversity, supply chains, or aquaculture. The rapid expansion and intensification of the seaweed industry with increasing new uses and cultivation diversification, requires working towards a shared vision for the future of the seaweed industry. Our goal at the International Seaweed Association is to ensure the continued development of seaweed and its benefits and to serve as a bridge between research academia and the industry. A sound science-based understanding of the different uses and applications of seaweeds should ensure that seaweed economies prosper in a sustainable way, as well as their market future needs. To develop a successful industry, research and cooperation are essential. We hope you find inspiration, solutions and cooperation to meet these challenges.

On behalf of the International Seaweed Association Council, we wish you a successful and fruitful participation in this 24 th ISS.

ISA INTERNATIONAL SEAWEED ASSOCIATION

Welcome from Convenors

Professors Catriona L Hurd and Michael Borowitzka

We warmly welcome you to the 24th International Seaweed Symposium in nipaluna/Hobart - both in person and on-line delegates!

When we chose the conference theme "Seaweeds in a changing world' in March 2020, we never imagined that a week later, a global pandemic would indeed change the world! As a result, we have adopted – for the first time in ISS history – a hybrid conference model that will allow unprecedented access to ISS presentations.

We are excited to share our beautiful island State lutruwita/Tasmania with the 500 in-person and 200 virtual delegates. We acknowledge the muwinina people who have cared for and protected Country for tens of thousands of years, and pay respect to Elders past, present and emerging.

This is the first time in its 75-year history that the ISS has been in the Australia/Aotearoa New Zealand region, and we are delighted to showcase and share our seaweed research, development and industry. We hope that you enjoy the pre-, post the mid-symposium workshops and tours, and the vibrant cultural activities that nipaluna/Hobart has to offer.

We also look forward to seeing your manuscripts submitted to the special volume of *Journal of Applied Phycology.*

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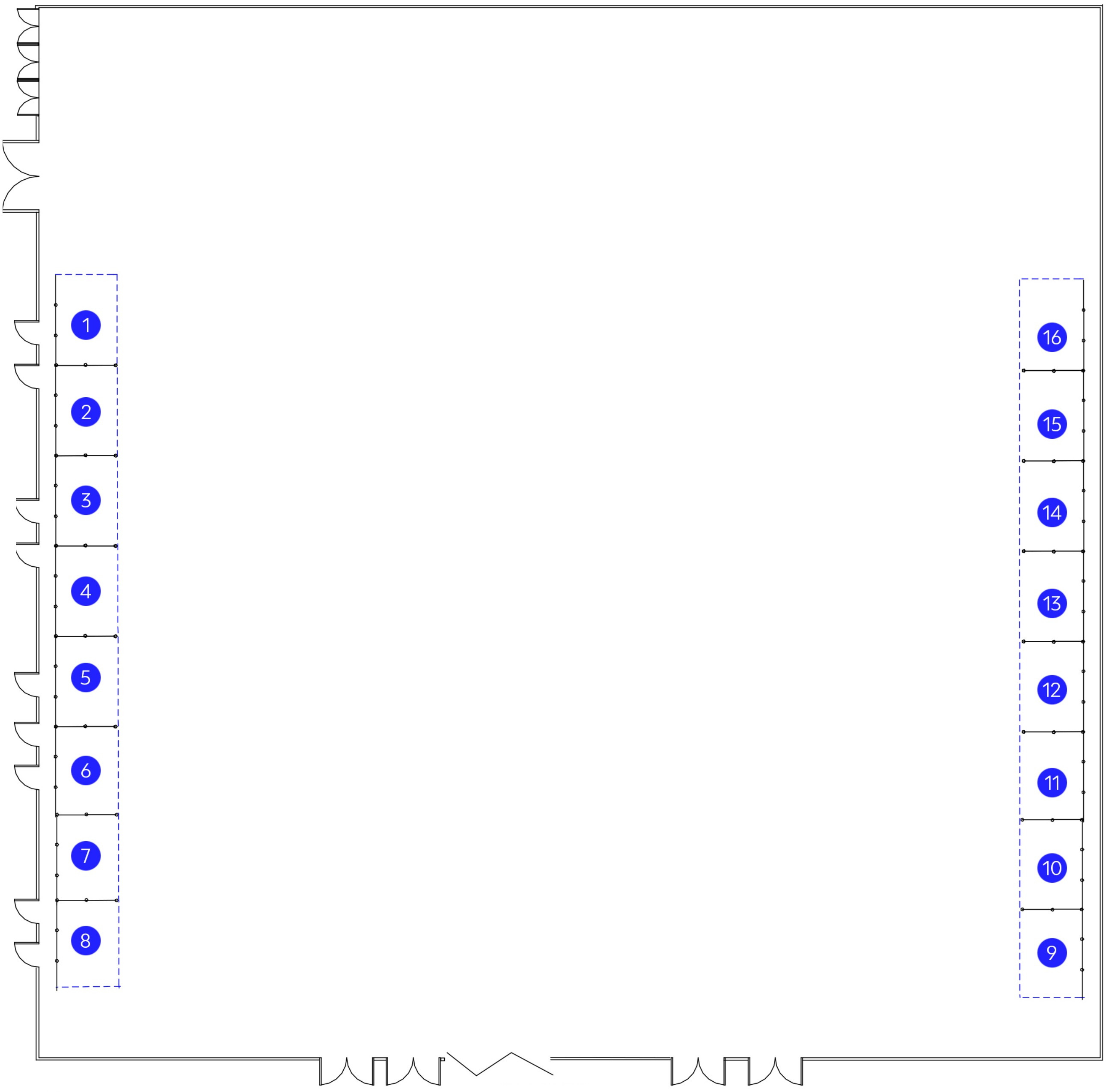

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Keynote Speakers

Melinda Coleman

NSW DEPARTMENT OF PRIMARY INDUSTRIES, AUSTRALIA

Melinda Coleman is a Principal Research Scientist with NSW Fisheries, Adjunct Professor at Southern Cross University and Associate Professor at the University of Western Australia. She has previously been an Australian Research Council Fellow and a postdoctoral fellow at the University of Maine, USA. Melinda leads a team of postdocs and students across government and university sectors to inform proactive marine management that anticipates and prepares for climate change. By melding ecology with genomics her team is providing new solutions for conserving and managing kelp forests in a future of increasing change. As a founding member of the Green Gravel action group and the award-winning Operation Crayweed team, Melinda is actively restoring lost kelp forests around Australia with the aim of boosting resilience to future climate change.

John Huisman

WESTERN AUSTRALIAN HERBARIUM, AUSTRALIA

John Huisman received his Ph.D. from the University of Melbourne in 1986 and soon after moved to Western Australia, spending the majority of the 1990s at Murdoch University undertaking a variety of phycological research projects. John's research has been primarily into the taxonomy of tropical seaweeds, an interest that began during his student years and flourished during a life-changing sojourn to the Hawaiian Islands in 2002-03. John is currently Curator at the Western Australian Herbarium, a position he has held since 2016. He has written over 200 scientific articles, plus numerous general interest articles on various aspects of seaweed biology. John has also written nine books, two of which were awarded the Prescott Award by the Phycological Society of America. John's most recent book is the revised version of 'Marine Plants of Australia' (2019), which describes over 600 species, illustrated by in-situ colour images and numerous line drawings.

Lim Phaik Eem

INSTITUTE OF OCEAN AND EARTH SCIENCES, UNIVERSITY OF MALAYA, MALAYSIA

Professor Dr. Lim Phaik Eem is the Deputy Director of the Institute of Ocean and Earth Sciences, University of Malaya. She is one of the founding members and the current secretary of the Consortium of Southeast Asian Seaweed Taxonomy (SEASTax). She has published more than 150 publications. Her main research focus has been on algae since the 1990s. With the challenges facing the carrageenan industries, especially lack of genetic diversity of cultivars of the eucheumatoids, she has initiated the study in Malaysia as well as in the Southeast Asian regions the past 10 years and the research scope is expanded with her involvement in GCRF GlobalSeaweedSTAR programme, where a problem-based multidisciplinary approach was adopted to address several main issues affecting the seaweed cultivation and processing industries. These include detection of diseases and pests associated with the seaweed farming, farm management and legislation (biosecurity), conservation and exploration of genetically diverse seed stocks, and socio-economic resilience of the industry.

Keynote Speakers

Chris Hepburn

UNIVERSITY OF OTAGO, NEW ZEALAND

For the last 15 years Assoc. Prof Hepburn has led transformative climate change, aquaculture and fisheries research and teaching programmes in partnership with coastal communities. Key to this work is building capacity and applying fit-for-purpose research to empower decision-makers to alter public policy surrounding marine management and ecosystem restoration. He co-leads Te Tiaki Mahinga Kai a research partnership programme with indigenous communities (primarily Ngāi Tahu) developed to better meet community aspirations and support local action by Tangata Tiaki/Kaitiaki (customary fishery managers). He has published more than 60 papers on macroalgal ecophysiology, climate change, and fisheries. Assoc. Prof Hepburn currently leads an active and diverse lab group and is committed to supporting the leaders of coastal communities and training the next generation of scientists equipped to gather and share the knowledge we need to traverse an uncertain future.

Dorte Krause-Jensen

AARHUS UNIVERSITY, DENMARK

Dorte Krause-Jensen is a professor in marine ecology and biodiversity at the Department of Bioscience and Arctic Research Center, Aarhus University, Denmark. Her research focuses on the ecology, role and nature-based solutions provided by marine vegetated ecosystems, particularly seagrass meadows and kelp forests. Key themes are 1) responses of marine vegetation to global and local pressures, 2) Arctic vegetation and climate change, 3) functional roles and ecosystem services of vegetated coastal ecosystems, emphasizing their capacity as carbon sinks (i.e. blue carbon) and nutrient sinks, 4) protection and restoration of marine vegetation as nature-based solutions to societal and environmental challenges 5) marine vegetation as indicator of ecosystem status and change. Her research portfolio includes basic, strategic and applied research and has wider societal impact due to her role as advisor to Environmental Authorities on environmental monitoring and management.

Marie Magnusson

UNIVERSITY OF WAIKATO, NEW ZEALAND

Dr Marie Magnusson leads the Entrepreneurial Universities Macroalgal Programme jointly funded by the New Zealand Tertiary Education Commission and the University of Waikato, with the objective to domesticate and develop bioproducts from NZ species of macroalgae to support a sustainable seaweed aquaculture industry. She leads a team of research fellows, technical officers, and post-graduate students to deliver leading-edge multi-disciplinary research in macroalgal biology and production, biotechnology, and bioproduct development, with a strong focus on industry engagement and commercial outcomes. Dr Magnusson's most recent research has focused on Ulva, Ecklonia, and Asparagopsis, including human health, ruminant livestock productivity, and pollution remediation applications.

During 2020, Dr Magnusson's team put its new macroalgal research facility (pictured) into operation. The facility is the first in NZ to provide state-of-the art infrastructure for seaweed cultivation from nursery stages to grow-out to deliver closed life-cycle aquaculture production of seaweed, and is quickly becoming the foundation of additional excellent research.

Keynote Speakers

Wendy Nelson

UNIVERSITY OF AUCKLAND, NEW ZEALAND

Wendy Nelson specialises in marine phycology, particularly the biosystematics of macroalgae of New Zealand, with research on floristics, evolution and phylogeny, as well as ecology, and life history studies. She is currently working on a range of projects including the systematics and biology of coralline algae, and on the regional floras of Manawatāwhi (Three Kings Islands), Rangitahua (Kermadec Islands) as well as in Fiordland and Stewart Island. Wendy is a Principal Scientist at NIWA in the biosystematics team and a Professor in the School of Biological Sciences at the University of Auckland.

Helen Fitton

RDADVISOR, AUSTRALIA

Dr J Helen Fitton has more than 20 years of experience in research and development, with a focus on the commercial extraction and application of marine algal polysaccharides. She has an extensive publication and patent record and has delivered numerous presentations. Dr Fitton holds a BSc (Hons) in Biochemistry from the University of Manchester, a MSc from University College London and a PhD in Applied Chemistry from Aston University. She is a Fellow of the Royal Society of Chemistry. For the last 23 years, Dr Fitton has lived in Tasmania and feels very fortunate make a home in such a wonderful part of the world.

Eun Kyoung Hwang

NATIONAL INSTITUTE OF FISHERIES SCIENCE, REPUBLIC OF KOREA

Fisheries Seed and Breeding Research Institute, National Institute of Fisheries Science

Eun Kyoung Hwang is a Senior Researcher at the Fisheries Seed and Breeding Research Institute, National Institute of Fisheries Science, Korea. She received a PhD degree at Pukyong National University, Busan, Korea. She worked as a post-doctoral fellow at the Marine Lab., Queen's University of Belfast, UK. She is currently involved in research on seaweed cultivation and breeding. Works mainly include; Ecological & aquacultural aspects of seaweeds, mass production of brown alga (*Sargassum, Ecklonia, Undariopsis* and *Silvetia*) and green alga (*Codium, Capsosiphone* and *Ulva*), hybridization of kelp species for strain improvement and elongation of culture period, and strain improvement of *Saccharina*.

Patrick Martone

UNIVERSITY OF BRITISH COLUMBIA, CANADA

Dr. Patrick Martone is a professor in the Botany Department at the University of British Columbia. Research in his lab spans a wide range of phycological topics, encompassing the biodiversity, biomechanics, ecophysiology, and evolution of seaweeds.

Dr. Martone thinks carefully about the functional morphology of seaweeds and the evolutionary innovations that permit seaweeds to survive along wave-swept rocky shores. His work on seaweed biomechanics considers not only the movement of thalli in flow, but the structural and chemical nature of seaweed materials to resist breakage. He uses phylogenetic and taxonomic methods to explore the morphological diversification of seaweeds through time, and he is well known for his research on the evolutionary gains and losses of flexible joints in segmented calcified algae.

His work on seaweed biodiversity has inspired renewed efforts to characterize and monitor hundreds of seaweed species along the Pacific coast of Canada and to better anticipate the physiological and ecological impacts of changing ocean conditions on seaweed communities.

Nick Paul

UNIVERSITY OF THE SUNSHINE COAST

Professor Nick Paul is a marine scientist at the University of the Sunshine Coast. He leads applied R&D on seaweed for new product development, based upon a platform of sustainable production. He is also project leader on international research for development projects, focussed on domesticating new strains, creating new culture techniques and developing bioproducts for farmed seaweed across the Indo-Pacific. His interests in Australia revolve around high-value products, including functional food and nutraceuticals for human health as well as bioactives for fish, livestock and agriculture more broadly. Nick's role combines research expertise with a strong focus on industry partnerships, innovation, intellectual property development and commercialisation.

Sébastien Jan

DIRECTOR EAST COAST, OCEAN FARMERS

Sébastien Jan is native from Brittany, on the west coast of France, a hotspot for seaweed where he used to harvest Chondrus crispus as a teenager.

Sébastien has always been passionate by ocean which drove him to Madagascar from 2004 to 2009, starting his career as a marine biologist. And later on, leading efforts to establish successful seaweed farming activity for the phycocolloids industry in the region.

From that experience, Sébastien became a seaweed enthusiast, convinced of its great potential, with a strong wish to actively participate in its development.

Following that path, Sébastien joined Cargill and its carrageenan business, where he spent 12 years as seaweed strategic sourcing project & sustainability manager. He has been travelling around the world, spending significant time in the field in producing countries, leveraging his technical expertise with seaweed producers, implementing innovative projects and acquiring significant market knowledge and its players.

More recently, he has been instrumental in developing The Red Seaweed Promise, Cargill's unique sustainability program, with the commitment to improve lives of seaweed producers and their communities while securing long term supply of red seaweed, to address major challenges he came across over the years.

Early 2021, Sébastien left Cargill to join Ocean Farmers, a well-established seaweed production company, bringing his ideas, passion and expertise to support their growth and ambitions to develop sustainable seaweed production & innovative aquaculture in Madagascar.

Sébastien is also actively contributing to various initiatives, promoting seaweed production with its great potential and services it brings for the planet.

Keynote Speakers

Alejandro H. Buschmann

ACADEMIC, UNIVERSIDAD DE LOS LAGOS

Dr. Alejandro H. Buschmann is Professor at i-mar Research Centre, the Centre of Biotechnology and Bioengineering and the Marine Agronomy Seaweed Holobiont at The Universidad de Los Lagos, Chile. He has produced over 150 papers on macroalgae and sustainable development of aquaculture and presently is editor in Chief of Algal Research, Associated Editor of Journal of Phycology, Journal of applied Phycology and Aquaculture Environment Interaction. Also Dr. Buschmann is a member of the Chilean Academy of Science and in 2018 he was awarded with the Honor in Scientia Marina given by the Chilean Marine Science Society for his scientific achievements.

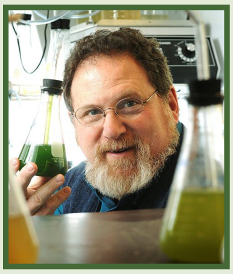
Karlotta Rieve

PROJECT MANAGER FOR THE INNOVATION SERVICES BUSINESS OF HATCH BLUE

Karlotta Rieve works as a Project Manager for the Innovation Services business of Hatch Blue, a global accelerator, investment and consultancy company for sustainable aquaculture. With the main focus of her work at Hatch around seaweed, she has most recently lead a study to assess the current state of seaweed farming in Asia. For this project she travelled to the main seaweed producing regions in East and South East Asia, to visit and collect data from 100+ farmers, processors, traders, researchers and innovative companies across 5 countries. Prior joining Hatch, Karlotta gained hands on experience with different aquaculture species, including seaweed cultivation on the Faroe Islands with Ocean Rainforest. With a Master in Innovation and Entrepreneurship from Denmark, has she been working in the food tech ecosystem, before strategically making her way into aquaculture.

Dr Ira 'Ike' Levine

CEO OF THE ALGAE FOUNDATION



Dr. Ira A. Levine, Ph.D. is a Emeritus Professor at the University of Southern Maine, who recently retired (12/31/2022) to become the CEO of the Algae Foundation. Dr. Levine was: selected as the 2017-2018 University of Southern Maine Trustee Professor; awarded 2016-2017 U.S. State Department's Distinguished Chair Fulbright and the 2009-2010 U.S. State Department's Fulbright New Century Scholar. In 2007-2008 he was a visiting professor of biology at Duke University. Dr. Levine combines 37 years of applied and basic research in the physiological ecology and cultivation of algae, aquatic farming management, and aquaculture engineering. His farming experience includes open-ocean and pond cultivation in Canada, China, Indonesia, Japan, Malaysia, Philippines, and USA (Hawaii, Florida, and Maine).

Dr. Levine has authored 36 publications, 90 presentations in 30 countries, 4 book chapters, 1 book and 2 edited books. 28 grants have been awarded totaling $ 7,025,000 over the course of the past 42 years.

Program

Program

Sunday 19th February 2023

PRE-SYMPOSIUM WORKSHOPS		
	Workshop One IMAS, 20 Castray Esplanade, Battery Point	**Workshop Two** IMAS, 20 Castray Esplanade, Battery Point
0900 – 1600	**How will biota respond to a changing ocean? A best practice guide for multiple drivers research** This workshop is available in person only.	**Charting a global agenda for kelp restoration** This workshop is available in person and online.
	Workshop Three IMAS, 20 Castray Esplanade, Battery Point	
1300 – 1600	**Towards a strategy for a global effort to address fundamental gaps in seaweed taxonomic knowledge** This workshop is available in person and online.	

TOURS

CSIRO Australian National Algae Culture Collection Tours
CSIRO, Castray Esplanade, Battery Point

Three tours of 35 – 40 minutes will take place at the following times:
2.00 – 2.40pm | 2.40 – 3.20pm | 3.20 – 4.00pm

Attendees will visit the CSIRO Australian National Algae Culture Collection. The algae collection is a unique resource of Australian biodiversity, containing living cultures of marine and freshwater species from most microalgal classes. Our strains have been sourced from tropical Australia to Antarctica.

1500 – 1900	Registration Open | Federation Ballroom Foyer

WELCOME RECEPTION

1700 – 1900	**WELCOME RECEPTION** **Federation Ballroom, Hotel Grand Chancellor Hobart** This is the first opportunity for all delegates to come together.

FutureFeed. Nature. Science. You.

Monday 20th February 2023

0730	Registration Open	Federation Ballroom Foyer
0900 – 1030	**PLENARY SESSION #1**	Federation Concert Hall
Please be in the room by 8:55am. Doors will be locked and no entry will be permitted once Her Excellency, the Governor of Tasmania, has entered the room.		
Chairs	**Catriona Hurd** **Michael Borowitzka**	
0900-0930	**Welcome & Opening Ceremony** Welcome to Country | **Alison Overeem** Official Opening | **Her Excellency the Honourable Barbara Baker AC, Governor of Tasmania** Welcome | **Professor Rufus Black, Vice Chancellor, University of Tasmania** Welcome by ISA President | **Daniel Robledo** Welcome by 2023 ISS Co-Chairs | **Professor Catriona Hurd & Professor Michael Borowitzka**	
0930 – 1000	**William Henry Harvey and his Australian Seaweeds** **John Huisman** Western Australian Herbarium, Australia	
1000 – 1030	**Rimurimu – Seaweeds of Aotearoa New Zealand – the journey of discovery continues…** **Wendy Nelson** University of Auckland, New Zealand	
1030 – 1100	**MORNING TEA & EXHIBITION**	Federation Ballroom
Federation Concert Hall		
Chairs	**Wei Zhang** **Alejandro Buschmann**	
1100 – 1230	**PLENARY SESSION #2**	Federation Concert Hall
1100 – 1130	**Future proofing kelp forests** **Melinda Coleman** NSW Department of Primary Industries, Australia	
1130 – 1200	**Contributing to the seaweed revolution: An overview of the cultivated red seaweed market, its challenges and vision to support the development of a sustainable supply chain – the case of Nosy Boraha Seaweed – Sainte Marie / Madagascar** **Sébastien Jan** Director East Coast, Ocean Farmers	

1200 – 1230	**Commercialising seaweed extracts** **Helen Fitton** Director, RDadvisor					
1230 – 1330	**LUNCH & EXHIBTION** **POSTER VIEWING SESSION – Theme 1A. Phycolloids and Bioactives**					Federation Ballroom
1330 – 1500	**CONCURRENT SESSION ONE**					
Theme	**MINI-SYMPOSIUM** **Global kelp forest restoration efforts – Part 1**	**MINI-SYMPOSIUM** **Australia-China Collaborations** NATIONAL FOUNDATION FOR AUSTRALIA-CHINA RELATIONS 澳中基金会	**ORALS** **Applications (Ruminants & animal fed)** marine bioproducts cooperative research centre	**ORALS** **Seaweed farming, harvesting and downstream processing (Ulva)** marine bioproducts cooperative research centre	**ORALS** **Physiology and 'Omics'**	**ORALS** **Taxonomy, Diversity and Evolution**
Room	Federation Concert Hall	Grand Ballroom 1	Grand Ballroom 2	Grand Ballroom 3	Harbour View 1	Chancellor 6
Chairs	Aaron Eger Thomas Wernberg	Jianhua Zhang Stephen Gray	Kirsten Heimann Cecilia Biancacci	Helena Abreu Wouter Visch	Juliet Brodie Cintia Iha	John Huisman Wendy Nelson
1330	**The Kelp Forest Alliance: A Global Home for Kelp Forests** **Aaron Eger**	**Kelp cultivar development in China: History, techniques and achievements** **Shao Jun Pang**	**Fucus species for methane reduction in dairy cattle** **Elizabeth Chassé**	**The lettuce of the sea: A 10-year history from an EU farmer** **Helena Abreu**	**Rainbow seaweeds: Exploring the physiology of structural colour in species of Chondria (Ceramiales, Rhodophyta)** **Margot Arnould-Petre**	**Genomic and multilocus analyses of Palmariaceae (Rhodophyta) from Southern Hemisphere confirm new additions in Devaleraea** **Danilo Bustamante**
1345	**Norwegian Kelp Forest Restoration** **Trine Bekkby**	**Role of seaweeds in alleviation Global Warming** **Jianhua Zhang**	**Enteric methane emission from dairy cows fed three brown seaweed species** **Mirka Thorsteinsson**	**Large-scale sea-based aquaculture of Ulv** **Sophie Steinhagen**	**Structural colour in the seaweeds: A phenomenon for our time?** **Juliet Brodie**	**An endemic epiphytic New Zealand red seaweed, Pyrophyllon subtumens, contains novel disaccharide repeat units** **Ruth Falshaw**

1400	**A review of tools and approaches to restore northern California's vanishing kelp forests** **Tristin McHugh**	**Novel Algal Extracellular Polymeric Substances (EPS)-based Hydrogels for the Efficient Removal and Recovery of Phosphorus from Contaminated Waters: Development, Characterisation, and Performance** **X Tan**	**Effects of feeding European seaweeds on performance, gas production and rumen microbiota in dairy cattle** **Wouter Muizelaar**	**A rapid methodology for the selection of Ulva elite strains tailored to specific growth conditions** **Clara Simon**	**From the bottom up: Climate change impacts on seaweed nutritional properties and marine food webs** **Tanika Shalders**	**Nuclei isolation to evaluate genome size of the red alga Gracilaria caudata using flow cytometry** **Leila Hayashi**
1415	**Kelp Conservation and Recovery in Puget Sound and the Pacific Northwest** **Betsy Peabody**	**Effects of Perfluorooctanoic Acid on Microcystis aeruginosa: Stress and self-adaptation mechanisms** **Jinlu Hu**	**Carbohydrate composition of 22 macroalgae species and their potential as future feeds for ruminants** **Elizabeth Chassé**	**Climate positive value chains from gentle harvest and processing of sea lettuce – mission possible?** **Marianne Thomsen**	**Ocean acidification increases porosity and reduces tissue strength in a non-calcifying foundation seaweed** **Alexandra Kinnby**	**Genomic analysis provides insights into the evolution of Ahnfeltia (Florideophyceae, Rhodophyta) and its divergence** **Hocheol Kim**
1430	**Lessons learned from the restoration of Cystoseira s.l. forests in the Mediterranean: Challenges and wins** **Annelisa Falace**	**Spatiotemporal dynamics of marine microbial communities following a Phaeocystis bloom: Biogeography and co-occurrence patterns** **Sha Xu**	**Australian brown seaweeds as a source of essential dietary minerals** **Vanessa Skrzypczyk**	**Harvest of sea lettuce as a tool for habitat restauration supporting the blue bioeconomy** **Anette Bruhn**	**Impacts of ocean warming and acidification combined, on physiological and biochemical composition of Ulva sp.** **João P. G. Machado**	**Geographic barriers for red seaweed in the Northwest Pacific: The case of Dichotomaria elegans** **Silvia Fontana**

1445	**Marine forest reforestation project of Korea Fisheries Resources Agency (FIRA)** Jin-woo Kang	**Technical and economic assessment of algae-based desalination** Li Gao	**DISCUSSION**	**DISCUSSION**	**Functional response of macroalgal communities as a tool for monitoring nutrient enrichment** Camille White	**Multilocus sequencing of Carlskottsbergia and "Synarthrophyton patena" from Southern hemisphere reveals a new Antarctic lineage** Martha S. Calderon
1500 – 1530	**AFTERNOON TEA & EXHIBTION**					Federation Ballroom
1530 – 1700	**CONCURRENT SESSION TWO**					
Theme	**ORALS** Seaweed farming & harvesting	**MINI-SYMPOSIUM** Bioplastics	**ORALS** Physiology and 'Omics (Asparagopsis)	**ORALS** Seaweed farming, harvesting and downstream processing (Biosecurity amd Certification)	**ORALS** Ecology	**MINI-SYMPOSIUM** Novel thermal macroalgae processing approaches to enhance valued compound extractions
Room	Federation Concert Hall	Grand Ballroom 1	Grand Ballroom 2	Grand Ballroom 3	Harbour View 1	Chancellor 6
Chairs	Jessica Knoop Allyson Nardelli	Fionnuala Quin Maria Cesário	Lachlan Mckinnie Olivia Wynn	Clare Bradley Sander Van Den Burg	Thomas Wichard Luna van der Loos	Jessica Adams
1530	**Seaweed Farming in Maine: A decade of development and innovation leading U.S. seaweed production** Jaclyn Robidoux	**Developments in algae-based biopolymers for food packaging applications** Marlene J. Cran	**A proteo-transcriptomic investigation of two life history stages for the red seaweed Asparagopsis taxiformis** Zubaida Parveen Patwary	**Safety in Seaweed; how to measure, mitigate and regulate** Sander Van Den Burg	**How do seaweeds acquire their microbial symbionts?** Syukur Syukur	**Steam explosion: A novel route for high value compound release from nuisance Ulva species** Jessica Adams

Program

1545	**Lessons Learned Growing Macrocystis Pyrifera in the Southern California Bight** Courtney Schatzman	**Development and characterization of enriched bioplastics made from whole seaweed and carrageenan for food packaging** Noumie Surugau	**In silico-based multi-omics approach to understanding Asparagopsis-organism interactions: Implications for aquaculture** Tomas Lang	**Can certification based on credible international standards help shape the growing seaweed industry?** Jo-anne McCrea	**Salinity structures the microbiome of the green seaweed Ulva: Functional and taxonomic patterns** Luna M. van der Loos	**The role of hydrothermal treatment in the extraction of high value fucoidan from macroalgae** Aaron Brown
1600	**Evaluation of environmental performance of Chinese kelp cultivation on industrial scale gives new insights** Kristina Bergman	**Ulva lactuca biorefinery: protein extraction for aquafeed and leftover carbohydrates for production of biodegradable bioplastics** Maria Teresa Cesário	**The effect of ocean warming and CO2 enrichment on Ecklonia radiata: Investigating molecular responses** Olivia Wynn	**Case Study of ASC-MSC Seaweed Sustainable Certification Program in Korea and Market Opportunities** Jongseok (Mark) Seo	**The green seaweed Ulva and its microbiome in a changing environment: Insights for new applications** Thomas Wichard	**Microwaves and seaweed: A novel thermal processing technology that can be implemented within seaweed biorefinery concepts** Emily Kostas
1615	**Saccharina latissima cultivation in the Belgian part of the North Sea: Challenges and lessons learned** Jessica Knoop	**Seaweed Biopackaging Economics and Ethical Supply: How to achieve both with integrated product streams and Fair Trade Agreements** Fionnuala Quin	**In silico investigation of red algal metabolic pathways using a multi-omics database** Lachlan Mckinnie	**From Garage to Greatness, a NZ Seaweed Story** Clare Bradley	**Unravelling the effects of microbiome manipulation in cultured Asparagopsis taxiformis** Silvia Blanco González	**DISCUSSION**
1630	**Lessonia corrugata aquaculture: seasonal cultivation and an innovative nursery approach** Allyson Nardelli	**Potentials and Feasibility of Seaweed Biopolymers** Thava Palanisami	**Proteomic analysis of the unicellular macroalga Caulerpa lentillifera** Asuka Arimoto	**A National Framework for a Sustainable Seaweed Sector in New Zealand** Nigel Bradly	**Bacterial controlled mitigation of dysbiosis in a seaweed disease** Jiasui Li	

1645	**DISCUSSION**	**Marine biodegradable and home compostable bioplastics derived from red seaweeds for packaging and single-use applications** **Hemanth Giri Rao Vantharam Venkata**	**Effect of salinity on the physiology of the seaweed Ulva sp. in a tropical environment** **João P. G. Machado**	**DISCUSSION**	**Preliminary Study on the Bacterial Infection occurred in Tank-cultured Sea Grapes, Caulerpa lentillifera J. Agardh** **Wahidatul Husna Zuldin**	
1700 – 1800	**POSTER RECEPTION** Federation Ballroom					
1800 – 1900	**GOVERNMENT HOUSE RECEPTION** By Invite Only Transport will be provided. Coaches depart 1745					

Tuesday 21st February 2023

0800	Registration Open	Federation Ballroom Foyer
0900 – 1030	**PLENARY SESSION #3**	Federation Concert Hall
Chairs	**Thomas Wernberg** **Catriona Hurd**	
0830 – 0900	**Macroalgae, blue carbon and nature-based solutions** **Dorte Krause-Jensen** AARHUS University, Denmark	
0900 – 0930	**Supporting community-led restoration of kelp forest ecosystems and associated fisheries** **Chris Hepburn** University of Otago, New Zealand	
0930 – 1000	**Asparagopsis exposé: 50-odd years of unique science and marketing** **Nick Paul** University of the Sunshine Coast, Australia	
1000 – 1030	**The international market for next generation seaweed products and applications – Findings from Hatch's global seaweed report** **Karlotta Rieve** Hatch Blue	
1030 – 1100	**MORNING TEA & EXHIBITION**	Federation Ballroom
1100 – 1230	**CONCURRENT SESSION THREE**	

Theme	**ASSA: Australian Seaweed Industry**	**MINI-SYMPOSIUM**	**ORALS**	**ORALS**	**ORALS**	**ORALS**
	Growing impact and opportunities	**Genomic selection in economically important kelp of the Eastern Pacific and North Atlantic**	**Seaweed farming, harvesting and downstream processing**	**Ecology (Indigenous knowledge)**	**Seaweed farming**	**Ecology**

Program

Room	Federation Concert Hall	Grand Ballroom 1	Grand Ballroom 2	Grand Ballroom 3	Harbour View 1	Chancellor 6
Chairs	Jo Kelly	Scott Lindell Charles Yarish	Stefan Kraan Manoj Kumar	Chris Hepburn Zoe Brittain	Nick Paul Pierre Liboureau	Cayne Layton Schery Umanzor
1100	**How the seaweed industry aligns to the Federal Government's agenda for aquaculture development, emissions reduction and regional development and the Government's support initiatives for seaweed industry development** **Brian Mitchel MP** **The Australian Seaweed Industry Blueprint and Implementation Plan** **Jo Kelly (ASSA)** **FRDC investment in the seaweed industry in the seaweed industry. Past, present and future** **Josh Fielding (FRDC)** **MBCRC program and investment in R&D for the seaweed industry** **Justin Coombs (MBCRC)**	**Genomic and genetic resources to accelerate breeding of brown seaweeds** **Mark Cock**	**Blue Economy: Social Media, Seaweed cowboys, hype and hoopla** **Stefan Kraan**	**Blue Carbon Science for Indigenous Sovereignty: A Diasporic Kanaka ʻŌiwi Methodology** **Andrew Kalani Carlson**	**Land-based cultivation of Codium tomentosum and Palmaria palmata, in Portugal** **Inês Oliveira**	**Engaging communities, grassroots activism, and the fight to save our giant kelp** **Senator Peter Wish-Wilson**
1115		**Selectively breeding improved strains of sugar kelp, Saccharina latissima; A four year summary** **Scott Lindell**	**SEAweed-Tech: A green, sustainable, zero-waste technology for seaweed bio-refinery and bioplastic** **Manoj Kumar**	**In discussion: Outcomes and experiences of a collaborative Aboriginal seaweed workshop in south-eastern Victoria** **Zoe Brittain**	**Macroalgae cultivation: Impacts of Mixotrophy, from strain selection to pilot scale cultures** **Erwan Le Gelebart**	**First restoration experiment for endemic Fucus virsoides on the western Istrian coast** **Edi Gljuscic**
1130		**Genetic tools for selection of heat tolerant cultivars of Saccharina latissima** **Zofia Nehr**	**Ready to go big? Scaling and quality issues for European cultivated seaweed for food** **Diogo Raposo**	**Developing cultivation protocols for two red Alaskan seaweeds with cultural relevance** **Muriel Dittrich**	**Developing hatchery-based reproduction methods for year-round production of Palmaria palmata in the North Atlantic** **Pierre Liboureau**	**Harnessing the power of citizen science to advance kelp farming in Alaska** **Schery Umanzor**

1145	**Seaweed Policy for a sustainable seaweed industry at scale** Shane Roberts, Angela Williamson, Karen Alexander, Christopher Ride	**Development of Genetics Based Selective Breeding of Sterile Giant Kelp** Gary Molano	**Assessment of a biorefinery methodology to produce high-value products from local harvested red macroalgae** Nuno Nunes	**Integrating Macro-Algae Culture into Alaska's Salmon Aquaculture: A unique teaching tool for students in Alaska** Angie Bowers	**Screening of seaweed species for cultivation associated with land-based aquaculture** Aires M. Durarte	**Habitat provisioning by a UK seaweed farm** Sophie Corrigan
1200		**Biphasic selection domestication in giant kelp** Brandon Vong	**Freezing and thawing methods to preserve the qualities of Ulva fenestrata as a food product** Céline Rebours	**Iron limitation of kelp growth may prevent ocean afforestation** Ellie Paine	**Targeting commercial scale production of Atlantic Nori Conchocelis** Madalena Mendes	**Photo elicitation as a method to investigate the seaweed value chain in Samoa** Ulusapeti Tiitii
1215		**The USA MARINER Program: Opportunities for the future expansion of scalable aquaculture and breeding programs** Charles Yarish	**The identification of potential food safety hazards for the processed seaweed for human consumption** Clare Winkel	**DISCUSSION**	**Comparison of farming and drying methods of seaweed and factors affecting its growth in Fiji** Albert Whippy	**Seaweed cultivation for nutrient management to supplement to nutrient removal processes in wastewater treatment** Shane Rogers

1230 – 1330	**LUNCH & EXHIBITION** **POSTER VIEWING SESSION – Theme 1B. Applications & 1C. Seaweed farming, harvesting and downstream processing**					Federation Ballroom
1330 – 1515	**CONCURRENT SESSION FOUR**					
Theme	**MINI-SYMPOSIUM** **Carbon sequestration by Macroalgae**	**MINI-SYMPOSIUM** **Precision Phyconomy**	**ORALS** **Seaweed farming** marine bioproducts cooperative research centre	**ORALS** **Applications** marine bioproducts cooperative research centre	**ORALS** **Ecology**	**ORALS** **Ocean Change and Climate Mitigation**
Room	Federation Concert Hall	Grand Ballroom 1	Grand Ballroom 2	Grand Ballroom 3	Harbour View 1	Chancellor 6
Chairs	Albert Pessarrodona Mat Vanderklift	Iain Neish Nelson Vadassery	Brenda Kranz	Teis Boderskov Fiona MacKechnie	Guillermo Diaz-Pullido Ellie Paine	Beth Strain Stephanie Roy
1330	**Carbon sequestration by macroalgae: Challenges and opportunities** **Albert Pessarrodona**	**Integration of precision technology into adaptive phyconomy systems for extensive tropical red seaweed farming** **Iain Charles Neish Neish (30-mins)**	**Developing sustainable seaweed aquaculture in New Zealand** **Jacob Nepper-Davidsen**	**Selection of local green algae species for growth in Integrated Multi-Trophic Recirculating Aquaculture Systems (IMRAS)** **Teis Boderskov**	**Induction of coral larval settlement by coralline red algae: Facilitators, inhibitors and possible mechanisms** **Guillermo Diaz-Pulido**	**Primary production in situ measurements on the subarctic kelp Saccharina latissima** **Stéphanie Roy**
1345	**Global and regional variation in seaweed export to potential carbon sinks** **Karen Filbee-Dexter**		**The feasibility of scalable coastal and offshore kelp mariculture in Alaska** **Michael Stekoll**	**Bioremediation, growth and yield of Ulva lacinulata in IMTA system with Abalone and Sea cucumber** **Abiodun Falade**	**Influence of substrate material and surface texture on algal colonisation and coral recruitment success** **Jenny Fong**	**Local adaptation across life stages and populations: Implications for Macrocystis pyrifera resilience to climate change** **Pamela Fernandez**
1400	**Developing tools and processes to measure, report, and verify carbon uptake, deposition, and sequestration rates on seaweed farms** **Nichole Price**	**Precision products from Precision Phyconomy** **Shrikumar Suryanarayan**	**Challenges and opportunities for kelp aquaculture in Tasmania, Australia** **Wouter Visch**	**Technical feasibility of integrating red macroalgae (Gracilariopsis tenuifrons) to a recirculating aquaculture system with clownfish** **Felipe Cohen**	**Impact of light on tropical crustose coralline algal communities growing on artificial substrates in aquaculture** **Soren Schipper**	**Effects of marine heatwaves on kelp Pterygophora californica from different depths in Baja California (México)** **Antonella Almeida**

1415	**Addressing key gaps hampering incorporation of kelp carbon in policy and finance frameworks** Mat Vanderklift	**Land-based precision phyconomy – lessons to be learned from microalgal production** Rui Pereira	**From the experimental to commercial cultivation: The establishment of the seaweed farming in South Brazil** Leila Hayashi	**Microbial dynamics of an integrated aquaculture system using seaweed as shrimp pond effluent biofilter** Cecilia Pascelli	**Competitive interactions in marine environments for space, light, nutrients, and herbivory in seaweeds** João Pedro Guimarães Machado	**Changes in Macrocystis pyrifera distribution in southern New Zealand correlated with elevated sea surface temperature** Ben Williams
1430	**Critical review of life cycle climate impact in seaweed value-chains to support carbon accounting** Jean-Baptiste Thomas	**Developing cultivation systems and best management practices for the precision phyconomy of Caribbean seaweeds in US waters** loretta Roberson	**Area-based management framework for the ecologically sustainable development of seaweed aquaculture in South Australia** Mandee Theil	**Stakeholder perceptions on the implementation of Integrated multi-trophic aquaculture (IMTA) in Tasmania: A Q-methodology approach** Lynnlee Chikudza	**Macroalgal physiological-ecology across an environmental gradient of submarine groundwater discharge conditions at Wai'alae, Hawai'i** Veronica Gibson	**Genetic structure of remnant giant kelp populations on the Tasmanian coast** Cintia Iha
1445	**DISCUSSION**	**A needs assessment for Precision Phyconomy Development in changing climates** Nelson Vadassery	**Regenerative Ocean Farming in New Zealand** Rebecca Barclay	**The growth of the mussel Perna canaliculus and the kelp Ecklonia radiata in co-culture mesocosm** Fiona MacKechnie	**Seasonal changes in Zonation of macroalgae on a tropical rocky shore** RMGM Thilakarathna	**Assessing the role of natural kelp forests in modifying seawater chemistry** Beth Strain
1500		**Deepwater irrigation rescues production of tropical seaweeds year-round: ramifications for temperate kelp-forest regeneration** Brian von Herzen	**DISCUSSION**	**Biomasonry products from macroalgae: A design driven approach to developing materials for carbon storage** Kate Scardifield	**Gametes of the green seaweed Ulva mutabilis (Chlorophyta) under cupric stress** Cristina Morales-Reyes	**Stipe of the kelp Eisenia bicyclis as a potential for long-lasting carbon sink** Delta Putra

1515 – 1545 **AFTERNOON TEA & EXHIBITION** Federation Ballroom

1545 – 1715 CONCURRENT SESSION FIVE

Program

Theme	MINI-SYMPOSIUM Global kelp forest restoration efforts – Part 2	MINI-SYMPOSIUM SeasolTM: Use of seaweed extracts in agriculture	ORALS Seaweed farming & harvesting	ORALS Seaweed farming, harvesting and downstream processing (Asparagopsi)	ORALS Applications	ORALS Ocean Change and Climate Mitigation
Room	Federation Concert Hall	Grand Ballroom 1	Grand Ballroom 2	Grand Ballroom 3	Harbour View 1	Chancellor 6
Chairs	Aaron Eger Wouter Visch	Tony Arioli Tim Sawbridge	Raul Ugarte Ralf Rautenberger	Jeff Wright Jessica Webb	Robbie Pott Cecilia Biancacci	Janet Kübler Cintia Iha
1545	**The Japanese perspective and action regarding seaweed bed restoration** Gregory N. Nishihara	**Applications of seaweed extracts in Australian agriculture** Tony Arioli	**Review of an ecosystem approach to the Ascophyllum nodosum harvest in Canada, 27 years later** Raul Ugarte	**The reproductive phenology of Asparagopsis armata in New Zealand – 35 years later** Alisa Mihaila	**The biochemical composition of Ulva spp. upon harvest time and colour separation** Signe Hjerrild Nissen	**Climate change resilience of Laminaria farlowii, a deep-water kelp from Southern and Central California, USA** Janet Kübler
1600	**Cascais Sea Strategy – Kelp Forests as a city's strategic objective in Sustainable Development** Ana Ferreira	**Effect of seaweed biostimulants on reactive oxygen species, disease suppression and higher yields in strawberry** Scott Mattner	**Ascophyllum nodosum Harvesting Impacts and Management Using GPS Tracking of Mechanical Harvesters in Canada** Joshua Sharp	**Effects of light intensity on bromoform biosynthesis and gene expression in Asparagopsis taxiformis** Jessica Webb	**Seaweed Solutions for Sustainable Aquaculture: Nutritional profiling of Australian kelps** Cecilia Biancacci	**Effects of Ocean Acidification and Irradiance on Growth and Recruitment of early successional Coralline Communities** Anna Kluibenschedl
1615	**Chilean kelps restoration, a review of past, progress, and opportunities by using chimeric kelps (R+D)** Alejandra Gonzalez Vasquez	**AGFORT, a red seaweed-based product and its implications in crop protection** Girish Tr	**Optimising kelp cultivation on the West coast of Scotland** Kati Michalek	**Effects of light quality and intensity on the growth and bromoform content of Asparagopsis taxiformis** Ana Campos	**Cultivation of red and green seaweed in natural saline lagoon: Chemical composition and extracts production** Maud Benoit-le Gélébart	**Exploring variable kelp resistance and resilience to climate-driven disturbances with Kelpwatch.org, a visualization web-tool** Vienna Saccomanno

1630	**Seaweed restoration in Australasia** **Adriana Verges**	**Effect of fortified Seaweed Extract on tomato physiology, productivity, fruit quality and soil properties** **Marianne Weisser**	**Strain selection for aquaculture of Saccharina latissima in a freshwater-influenced fjord system in North Norway** **Ralf Rautenberger**	**Patterns of expression in the sea: Biophysical influences on halogenated natural products in Asparagopsis** **Alexandra Campbell**	**Cultivating seaweeds in food production process waters – a circular approach to producing blue proteins** **Kristoffer Stedt**	**Carbon dynamics in a macroalgal habitat of Korea** **Ja-Myung Kim**
1645	**Piloting bull kelp (Nereocystis luetkeana) cultivation strategies to support kelp restoration and recovery in California** **Kendall Barbery**	**AgroGain®, prepared from Kappaphycus improves growth of Cucumis Sativa by modulating developmental and physiological processes** **Pushp Sheel Shukla**	**SeaMark: Seaweed Based Market Applications** **Ólavur Gregersen**	**Research to inform Asparagopsis armata cultivation in Tasmania** **Jeff Wright**	**Solubilisation of waste biomass from Ecklonia maxima processing** **Robbie Pott**	**How spatial resolution modify the seaweed covers estimation? Comparative study in Brittany using vegetation indices** **Wendy Diruit**

1700	**The value of the world's kelp forests** **Thomas Wernberg**	**Study of holopelagic Sargassum in carribean coasts: Development of extracts for agriculture application** **Maud Benoit-le Gélébart**	**DISCUSSION**	**DISCUSSION**	**DISCUSSION**	**Mapping Sargassum meadow for estimation of biomass using side scan sonar** **Hajime Okawa**
1730	**AUSTRALIAN SUSTAINABLE SEAWEED ALLIANCE SEAWEED INNOVATION SHOWCASE AND NETWORKING EVENT** Harbour View 1					
1730	**EARLY CAREER RESEARCH (POSTDOCTORAL) FUNCTION** Grand Ballroom 1 The Early Career Function is available for delegates who are up to 7 years post PHD. Attendees will head to Hobart Brewing Co following the function					
1730	**STUDENT FUNCTION – IMAS**					

Wednesday 22nd February 2023

MID-SYMPOSIUM TOURS — Federation Concert Hall

The below tours are available for onsite delegates to book at an additional cost, where applicable. Prices are in Australian Dollars and include GST.
You can book these when registering or add them to your registration at a later date. Please note tours have capped numbers and are available on a "first come, first served basis".

HALF DAY TOURS – MORNING — Federation Concert Hall

HOBART HISTORY, PEOPLE & PLACES WALKING TOUR

Time: 10:00 – 12:00
Cost: $38pp AUD
Departure: Hotel Grand Chancellor
Return: Salamanca Place

HALF DAY TOURS – AFTERNOON — Federation Concert Hall

IRON POT CRUISE

Time: 13:45 – 16:30 (please be at the booking centre to check in at 13:45)
Cost: $135pp AUD
Departure: Pennicott Wilderness Journeys Booking Centre | Franklin Wharf
Return: Pennicott Wilderness Journeys Booking Centre | Franklin Wharf

ALL DAY TOURS	Federation Concert Hall
BRUNY ISLAND TRAVELLER	TASMAN ISLAND CRUISE & PORT ARTHUR
Time: 07:15 – 17:30/18:00 (7:15 am sharp departure – booking centre opens at 7 am) **Cost**: $210pp AUD **Departure**: Pennicott Wilderness Journey's Booking Centre | Franklin Wharf **Return**: Hotel Grand Chancellor	**Time**: 07:30 – 18:00 **Cost**: $280pp AUD **Departure**: Pennicott Wilderness Journey's Booking Centre | Franklin Wharf **Return**: Hotel Grand Chancellor
BONORONG WILDLIFE SANCTUARY	DIVING
Time: 11:45 – 15:20 **Cost**: $85pp AUD **Departure**: Hobart Grand Chancellor **Return**: Hotel Grand Chancellor	**Time**: Group 1 – 006:45 – 16:00 (approx) Group 2 – 10:00 – 19:30 (approx) **Cost**: $370 AUD. The price includes transfers (approx 1 hour 15 minutes journey) packed lunch, 2 dives at different sites and full gear hire. Numbers are limited. **Departure**: Hobart Grand Chancellor **Return**: Hotel Grand Chancellor

Thursday 23rd February 2023

0800	Registration Open	
0830 – 1000	**PLENARY SESSION #4**	Federation Concert Hall
Chairs	**Rocky De'Nys** **Leonardo Mata**	

0830 – 0900	**Current trends and future prospects of seaweed cultivation and breeding in Korea** **Eun Kyoung Hwang** National Institute of Fisheries Science, Republic of Korea
0900 – 0930	**Seaweed aquaculture in Aotearoa New Zealand – from bucket science to implementation** **Marie Magnusson** University of Waikato, New Zealand
0930 – 1000	**Global and local marine agronomical trends: developmental facts or only good desires?** **Alejandro H. Buschmann** Centro i-mar, CeBiB & MASH, Universidad de Los Lagos, Puerto Montt, Chile
1000 – 1030	**MORNING TEA & EXHIBITION** — Federation Ballroom
1030 – 1200	**CONCURRENT SESSION SIX**

Theme	**MINI-SYMPOSIUM** **Kelp Blue: Macrocystis cultivation and ocean health**	**ORALS** **Seaweed farming** marine bioproducts cooperative research centre	**ORALS** **Ecology**	**ORALS** **Ocean Change and Climate Mitigation**	**ORALS** **Phycolloids and Bioactives** marine bioproducts cooperative research centre	**MINI-SYMPOSIUM** **Seaweed-derived sterols in aging-related diseases**
Room	Federation Concert Hall	Grand Ballroom 1	Grand Ballroom 2	Grand Ballroom 3	Harbour View 1	Chancellor 6
Chairs	Caroline Slootweg	Craig Johnson Michael Stekoll	Put Ang Hunter Forbes	Ju-Hyoung Kim Hagen Buck-Wiese	Benoit Queguineur Fanny Lalegerie	Monique Mulder Tim Vanmierlo
1030	**Macrocystis pyrifera cultivation at scale: How the industry can think big, but stay focused** **Daniel Hooft**	**Developing production systems for offshore kelp mariculture in SE Australia** **Craig Johnson**	**Can morphology or photobiology explain the farming success of Macrocystis multiple frond morphotype?** **Alejandro Buschmann**	**Where does all the seaweed carbon go?** **Ellyn Erlania**	**Leveraging the NIST Dietary Supplement Laboratory Quality Assurance Program for the Compositional Analysis of Seaweeds** **Jenna Klingsick**	**The use of seaweed-derived phytosterols to defeat Alzheimer's Disease** **Nikita Martens**

Program

1045	**Kelp Blue learnings to date about setting up a seaweed farm, the good, the bad and the ugly** **Josh Masel**	**A Collaborative Platform for Growth: The GreenWave Regenerative Ocean Farming Hub** **Samantha Garwin**	**Patterns of growth and productivity in Ascophyllum nodosum populations from a wide geographical range** **Jean-Sebastien Lauzon-Guay**	**Kelp dissolved organic carbon release is variable, passive, and decoupled from photosynthetically active radiation** **Andrew Kalani Carlson**	**VARECH project: Valorization of beach-cast seaweeds in Normandy (France)** **Benoit Queguineur**	**Potential of Himanthalia elongata in the treatment of Alzheimer's disease** **Monique Mulder**
1100	**Moving beyond the ocean: Commercialisation of seaweed products for agriculture (and other industries) and how it contributes to the wider shift to sustainability** **Caroline Slootweg**	**Scaling of seaweed cultivation: Site selection and (bio) technical solutions for cost-effective farm operations** **Job Schipper**	**Mannitol as a Resource for the Growth and Reproduction of Sargassum siliquastrum (Turn.) Ag.** **Put Jr Ang**	**Brown algae inject fucoidan carbon into the ocean** **Hagen Buck-Wiese**	**Selection and sustainable valorization of Irish macroalgae by integrating natural variability (BlueBio MINERVA)** **Fanny Lalegerie**	**24(R, S)-Saringosterol – from artefact to a biological medical agent** **Dieter Lütjohan**
1115	**Biostimulants global market overview and trends/ predictions** **Samantha Deane**	**Exploring the Kelp Farm Design Tool: An interactive planning tool on GreenWave's Ocean Farming Hub** **Kendall Barbery**	**Unravelling the secret life of MAD gametophytes** **Alexander Ebbing**	**Estimation of CO2 sequestration potential by population- and community-level metabolism of artificial seaweed beds** **Ju-Hyoung Kim**	**Future protein supply from tropical seaweed: An exploration** **Asmi Citra Malina A.R. Tassakka**	**Dietary Sargassum fusiforme improves memory and reduces amyloid plaque load in an Alzheimer's disease mouse model** **Tim Vanmierlo**

1130	**DISCUSSION**	**Upscaling open ocean kelp cultivation and offering an economic performance study of the operation** **Ólavur Gregersen**	**Thermal tolerance of the giant kelp (Macrocystis pyrifera)** **Duong Minh Le**	**Determining the fate of Laminaria hyperborea detritus in the Irish Sea using species-specific DNA markers** **Molly Crowe**	**Seaweed beach-casts: Are these valuable and safe resources?** **Nuno Nunes**	**DISCUSSION**
1145		**DISCUSSION**	**Farms and forests: Evaluating the biodiversity benefits of kelp aquaculture** **Hunter Forbes**	**DISCUSSION**	**DISCUSSION**	
1200 – 1300	**LUNCH & EXHIBITION** **POSTER VIEWING SESSION – Theme 2. Ecology**					Federation Ballroom
1300 – 1445	**CONCURRENT SESSION SEVEN**					
Theme	**MINI-SYMPOSIUM** **Best Practice in Post-harvest treatment of seaweed**	**MINI-SYMPOSIUM** **Securing the future of the eucheumatoid seaweed industry in a time of rapid environmental change**	**ORALS** **Applications** marine bioproducts cooperative research centre	**ORALS** **Phycolloids** marine bioproducts cooperative research centre	**ORALS** **Ecology**	**ORALS** **Applied and Industry – Use of seaweed extracts in agriculture** marine bioproducts cooperative research centre
Room	Federation Concert Hall	Grand Ballroom 1	Grand Ballroom 2	Grand Ballroom 3	Harbour View 1	Chancellor 6
Chairs	Susan Holdt Jennifer Perry	Anicia Hurtado Michael Roleda	Scott Spillias Isobel Sousa Pinto	Helen Fitton Nanna Rhein-Knudsen	Brenton Twist Loretta Roberson	Anicia Hurtado Michael Roleda

1300	**Blanching of fresh sugar kelp should remove the fear and market barrier** Susan Løvstad Holdt	**Towards an Integrated Platform for Eucheumatoid Cultivar Development** R A Narayanan	**Suitability of world seas and oceans for seaweed cultivation** Pepijn Van Oort	**Enzymatic extraction of high purity fucoidans from brown seaweeds** Nanna Rhein-Knudsen	**Understanding drivers of kelp distribution and loss to inform kelp forest restoration in New Zealand** Dallas Lafont	**Untargeted metabolomics analysis reveals different profiles of Arabidopsis thaliana following treatment with seaweed extract** Chi T.L. Tran
1315	**Investigating microwave-vacuum drying, freeze drying and hot air drying of Ulva spp and Fucus vesiculosus** Susan Løvstad Holdt	**Innovative measures for growing eucheumatoids and mitigating ice-ice and epiphyte incidences using Ascophyllum nodosum extract** Anicia Hurtado	**Expert perceptions of seaweed farming for sustainable development** Scott Spillias	**Blanching before pH-shift processing of Saccharina latissima retains protein extraction yields while minimizing iodine content** João Trigo	**Importance of substrate complexity, snail abundance and exposure on the recruitment success of Ascophyllum nodosum** Bryan Morse	**Pathways to function: 'Omics' reveals how seaweed-derived biostimulants enhance plant productivity and reduce biotic stress** Md Tohidul Islam
1330	**Brining as a stabilising method for Ulva fenestrate biomass** Mar Vall-llosera Juanola	**Tetrasporogenesis and sexual reproduction in Kappaphycus alvarezii for new seedstock development and selective breeding** Lourie Ann Hinaloc	**Nature's Contributions to People derived from seaweed aquaculture** Isabel Sousa Pinto	**Optimisation of cellulase-assisted extraction of laminarin from the brown seaweed Ecklonia maxima** Neill Goosen	**Kelp and urchin settlement on coralline algal species with implications for kelp forest recovery** Brenton Twist	**RNASeq analysis of Seasol treatment of growth media on the lettuce seedling root transcriptome** Tim Sawbridge
1345	**Safety, physicochemical attributes and consumer acceptance of Saccharina latissima preserved by salting** Jennifer Perry	**Effects of nutrient supply on growth and biochemistry of Kappaphycus alvarezii** Tom Gerald Genovia	**Achieving social license to operate for seaweed farms across geographic contexts** Bailey Moritz	**Blue cellulose: The challenge of producing fibre grade cellulose from seaweed** Jaap van Hal	**Restoration of seaweed forests in Korea: A series of experimental works for last 7 years conducted on the urchin barrens habitats** Jeong Ha Kim	**Evaluating the phytotoxicities of two Irish red seaweeds against some common weed species** Onyedika Chukwuka Chukwuma

1400	**Influence of storage time and dehydration methods on microbiological and physiochemical quality of brown seaweeds** Jonas Steenholdt Sørensen	**Development and Application of Molecular Genetic Resources for the Advancement of Kappaphycus alvarezii** Scott Fahrenkrug	**Indonesian red seaweeds are a potential sourse of mycrosporine-like amino acid and hydrocolloid for cosmeceuticals** Noer Kasanah	**Ulvan from filamentous and blade species of Ulva (chlorophyta) differ in structural and chemical composition** Joel Kidgell	**Differences in recovered community assemblage depending on the removal of sea urchins and other herbivores, coupled with transplant of Ecklonia bicyclis** Seokwoo Hong	**Effect of seaweed extract on avocado root growth, yield and post-harvest quality in Queensland, Australia** Tony Arioli
1415	**Towards more successful seaweed fermentations: Screening approaches and potential of lactic acid bacteria fermentation in Nordic brown seaweed Saccharina latissima** Evangelia Zioga	**Regeneration and development of enzymatically-isolated protoplasts of Kappaphycus spp. (Solieriaceae, Rhodophyta)** Ronelie Salvador	**DISCUSSION**	**To gel or not to gel: Enzymatic desulfation of carrageenans to modify their rheological properties** Volker Sieber	**Restorative aquaculture: Quantifying the environmental and social benefits of seaweed farming** Shelby Schumacher	**The competitiveness of Indonesia's seaweed products in the international market** Syamsul Pasaribu
1430	**DISCUSSION**	**Impacts of aquaculture nutrient sources: ammonium uptake of commercially important eucheumatoids depends on phosphate levels** Bienson Ceasar Narvarte		**Structural and biochemical characterization of degraded iota carrageenan using enzyme produced by Cellulophaga baltica** Sanjida Humayun	**DISCUSSION**	**Tropical seaweed extract based agro bio-stimulant 'SAGARIKA' in combination with nano urea for better crop health and higher crop production in rice** Munisamy Shanmugam
1445– 1515	**AFTERNOON TEA & EXHIBITION**					Federation Ballroom

1515 – 1700	CONCURRENT SESSION EIGHT					
Theme	**MINI-SYMPOSIUM** What does a sustainable tropical seaweed industry look like?	**Safe Seaweed Alliance**	**ORALS** Seaweed farming & harvesting	**ORALS** Seaweed farming, harvesting and downstream processing	**ORALS** Bioactives	**ORALS** Ecology
Room	Federation Concert Hall	Grand Ballroom 1	Grand Ballroom 2	Grand Ballroom 3	Harbour View 1	Chancellor 6
Chairs	Nicholas Hill Micheal Roleda	Philippe Potin Vincent Doumeizel	Marie Magnusson Rebecca Lawton	Nick Paul Libby Swanepoel	Patricia Matanjun Dang Diem Hong	Chris Cornwall Georgina Wood
1515	Critical considerations for building a regenerative seaweed value chain **Nicholas Hill**	From the Seaweed Manifesto to the Seaweed Revolution **Vincent Doumeizel**	Seaweed Aquaculture – The Opportunities for Tasmania and Australia **Catriona Macleod**	Biorefinery of Ulva spp. and evaluation of food quality of resulting protein concentrate **Trine Kastrup Dalsgaard**	ALGAE4IBD: Searching for IBD treatment in algal diversity **Benoit Queguineur**	Temporal variation in distribution, abundance, and reproduction of Cystophora torulosa and Caulocystis uvifera in Victoria **Daniel Vairo**
1530	Seaweed cultivation in Madagascar – developing an aquaculture model based on risk mitigation approach and coastal communities to ensure a growing and sustainable seaweed supply chain **Sébastien Jan**	The Science behind the Safe Seaweed Coalition and the European Perspective **Philippe Potin**	Optimising the zoospore release, germination, development of gametophytes and formation of sporophytes of Ecklonia radiata **Rebecca Lawton**	Protein extraction increases the N digestibility of sea lettuce protein **Louise Juul Pedersen**	Screening of compounds/ extracts with neuroprotective activity from Vietnam seaweeds **Dang Diem Hong**	Morphological and genetic analysis of Eisenia arborea along the Pacific Coast of Baja California, Mexico **Jose Zertuche-Gonzalez**

1545	**Status and requirements in the genetic diversity of commercial eucheumatoid industry** Michael Roleda	**Underexploited potential of the seaweed aquaculture in the non-asian Indo-Pacific region** Lydiane Mattio	**European seaweed cultivation: Optimising seeding techniques for Saccharina latissima** Catherine Wilding	**Valorization of Ulva sp. for production of fungal biomass protein using T. reesei** Maria Elena Lienqueo	**Phlorotannin-loaded gold nanoparticles for innovative skin health products** Adele Mastroyannis	**Genetic tools to inform and future-proof global upscaling efforts to conserve, restore and farm kelp** Georgina Wood
1600	**Conservation International Ventures and Konservasi Indonesia presents the Coral Triangle Seaweed Strategy – unlocking benefits for people and planet across the value chain** Gracie White	**SecureFuture: Selection and curation of safe and healthy eucheumatoid seedlings for the future** Michael Roleda	**Seasonal and site-specific differences in growth and sporophyte production of Ecklonia radiata gametophytes** Jakop Schwoerbel	**Why do young adults eat seaweed? An Australian case study** Mikeala Young	**Fucoidan enhances human immune cell activities and stops prostate cancer cell growth with Nivolumab** Corinna Dwan	**Experimental assessment of environmental versus genetic influences on giant kelp (Macrocystis) morphology** Sara Gonzalez
1615	**Technology gaps, innovation opportunities and new markets for a productive and scalable eucheumatoid seaweed industry – Insights from Hatch's global seaweed report** Karlotta Rieve	**The Coalition for Safe Seaweeds in the Americas** Leila Hayashi, Alejandro Buschmann	**Effect of growth parameters on Macrocystis pyrifera (giant kelp) sporophytes for bioproduct production** Diane Purcell	**Algae for novel and healthy pasta** Susana Mendes	**Anti-Inflammatory, Anti-Aging and Wound-Healing Potential of Polysaccharides from Seven Red Algal Species of Commercial Interest** Amal Premarathna	**DNA markers for cross-breeding and improving cultivation of the editable brown alga, Cladosiphon okamuranus** Koki Nishitsuji

1630	**The connection between seaweed farming practices and local marketing systems in two Indonesian villages** **Alexandra Langford**	**The African projects supported by the Safe Seaweed Coalition** **Sebastien Jan, Frederic Pascal**	**A comparison of novel seeding approaches for upscaling Giant kelp (Macrocystis pyrifera) cultivation** **William Klingbeil**	**Proximate composition and sensory evaluation of noodles fortified with green seaweed, Caulerpa lentillifera powder** **Nur Syakilla**	**Antioxidant and anticancer activities of Malaysian seaweed, Sargassum polycystum extracts against human cancer cell lines** **Patricia Matanjun**	**Conditions influencing abundance of 'green tide' macroalgae in a tropical intertidal zone of Southern Philippines** **Ephrine Metillo**
1645	**The Sinofiication of carrageenan seaweed processing and implications for Indonesia** **Dr Zhang Jing**	**The Seaweed Hub in the United States** **Jaclyn Robidoux**	**The effects of mechanical harvesting on Ascophyllum nodosum and associated invertebrates** **Alison Feibel**	**The effect of iodine reducing processing methods on the sensory profile of Saccharina latissima** **Johanna Liberg Krook**	**Antioxidant potential of purified phlorotannins from Australian fucoids for the food industry** **Flora Lam Kim**	**Species identification for a crustose calcifying red algal community that induces Acropora surculosa recruitment** **Mari Deinhart**
1900 – 2330	**SYMPOSIUM DINNER** Transport provided – coaches depart 1845					Tasman Room, Wrest Point

Friday 24th February 2023

0800	Registration Open	
0830 – 1000	**PLENARY SESSION #5**	Federation Concert Hall
Chairs	**Wendy Nelson** **Michael Borowitzka**	

0830 – 0900	**Safeguarding the carrageenophyte cultivation industry: A case study in Malaysia** **Lim Phaik Eem** Institure of Ocean and Earth Sciences, University of Malaya, Malaysia
0900 – 0930	**Consequences of calcification for coralline algal ecology and evolution** **Patrick Martone** University of British Columbia, Canada
0930 – 1000	**Algae Foundation's algal-based education and workforce development; a global initiative developing bioeconomy professionals** Stefan Kraan will present on behalf of Ira "Ike" Levine; Ike will join for live Q&A
1000 – 1030	**MORNING TEA & EXHIBITION** Federation Ballroom
1030 – 1215	**CONCURRENT SESSION NINE**

Theme	**ORALS** **Seaweed farming, harvesting and downstream processing** marine bioproducts cooperative research centre	**ORALS** **Ocean Change and Climate Mitigation**	**ORALS** **Ecology**	**ORALS** **Phycolloids and Bioactives** marine bioproducts cooperative research centre	**ORALS** **Taxonomy, Diversity and Evolution**	**ORALS** **Bioactives** marine bioproducts cooperative research centre
Room	Federation Concert Hall	Grand Ballroom 1	Grand Ballroom 2	Grand Ballroom 3	Harbour View 1	Chancellor 6
Chairs	Jennifer Hudson Joshua Masel	Lauren Bell Damon Britton	Louise Kregting Celina Burkholz	Maria Gil Neil Goosen	Mariana Oliveira Seok Wan Choi	Joao Trigo Courtney Anderson
1030	**The principals and application of direct seeding for seaweed cultivation** **Joshua Masel**	**Effects of multiple drivers of change on seaweed from Aotearoa New Zealand** **Christopher Cornwall**	**Limits and thresholds to seaweed farming, a theoretical approach to carrying capacity for seaweed farming** **Sophie Koch**	**Recovery and bioactivity of volatile halogenated natural products from post-harvest processing of Asparagopsis taxiformis** **David Heyne**	**Integrating metabolomics and DNA to uncover diversity patterns in species of Ecklonia from southern Africa** **Maggie Reddy**	**Health benefits of consuming seaweed – a myth or clinically proven?** **João Trigo**

1045	**Macroalgae cultivation materials: Assessing chemistry and microstructure for a reliable, cost-effective seeding solution** Ruben Marques	**Environmental change at the fringe: Seasonally distinct responses of kelps within high latitude Macrocystis beds** Lauren Bell	**Effects of slow-release fertilizer and blue light on Undaria pinnatifida growth in the cultivated field** Huiling Lin	**The kinetics of ultrasound-assisted alginate extraction from Ecklonia maxima with and without cellulase addition** Neill Goosen	**Sargassum diversity on the Brazilian coast: a new interpretation based on molecular data** Mariana C Oliveira	**Seaweed for food and beverage innovations– what do the ‘makers’ want?** Coutney Anderson
1100	**A practical application for urchin conspecific alarm cues as feeding deterrent** Dominic Franco C. Belleza	**Physiological responses of the kelp Eisenia arborea in artificial deep refugia in Baja California, Mexico** Jose Miguel Sandoval Gil	**Moving may be a good thing: How water motion influences the cultivation of Saccharina latissima** Louise Kregting	**Investigating the Functionality of the Ulvan Utilising Plasmid in Alteromonas sp. 76-1** Valerie Rodrigues	**Elucidation of the brown algal gamete evolution with a new timeframe and organelle data** Seok-Wan Choi	**Contribution of seaweed to health and nutrition in Samoa: A dietary modelling simulation study** Libby Swanepoel
1115	**RNA-Seq analysis reveals a downregulation of immune associated genes in Delisea pulchra following pathogen exposure** Jennifer Hudson	**Intraspecific variation in thermal tolerance, and restoring Australia’s disappearing giant kelp (Macrocystis pyrifera) forests** Cayne Layton	**Effects of in situ variation in kelp productivity on gametophyte performance** Celina Burkholz	**Optimization of pre-treatments, frozen storage and thawing to increase the shelf life of sugar kelp** Celine Rebours	**Organelle phylogenomics of the genus Vaucheria reveals the evolutionary history and unique mitochondrial genome structure** Jihoon Jo	**Exploring the development of Australian seaweed ingredients for food and beverage products** Saskia de Klerk
1130	**Process water of whiteleg shrimp Litopenaeus vannamei can be used to fertilize macroalga Caulerpa lentillifera** Lara Elizabet Stuthmann	**A knowledge synthesis of nutritional quality and climate performance for Saccharina latissima** Jean-Baptiste Thomas	**Soft sediment macroalgal communities of Otago Harbour, New Zealand** Namrata Chand	**Phenolic compounds content and antioxidant activity of wild macroalgae Ulva sp. vs cultivated Ulva rigida** Maria M Gil	**Seaweed biobanking at the Culture Collection of Algae and Protozoa: Preserving diversity for the future** Cecilia Rad – Menéndez	**Seaweeds for novel and healthy food products: Sea sausages as a case study** Susana Mendes

1145	**The ups and downs of water quality within a commercial recirculating IMTA Abalone/Ulva system: Effects of increased recirculation on critical parameters** **Mark Cyrus**	**Thermal performance of the habitat forming kelp Ecklonia radiata under ambient and elevated CO2 levels** **Damon Britton**	**Analysis of pelagic sargassum biomass harvested in Jamaica** **Thierry Tonon**	**Chemical structures of phlorotannins from six brown seaweed species and their antibacterial and antioxidant activities** **Nolwenn Kergosien**	**DISCUSSION**	**DISCUSSION**
1200	**DISCUSSION**	**Ecology of kelp gametophytes: grazing in a warming ocean** **Reina Veenhof**	**Effects of climate change and species facilitation on the restoration of shallow marine forests** **Margalida Monserrat**	**Evaluation of the isolation and purification of milk-clotting enzymes from marine macroalga Gracilaria edulis** **Ariestya Arlene Arbita**		
1215 – 1315	**LUNCH & EXHIBITION** Federation Ballroom **POSTER VIEWING SESSION – Theme 3. Ocean Change and Climate Mitigation, Theme 4. Physiology and 'Omics' & Theme 5. Taxonomy, Diversity and Evolution**					
1315 – 1420	**CONCURRENT SESSION TEN**					
Theme	**ORALS** **Ecology (Kelps)**	**ORALS** **Applications**	**ORALS** **Tropical Seaweed farming, harvesting and downstream processing**	**ORALS** **Ecology**	**ORALS** **Phycolloids and Bioactives**	
Room	Federation Concert Hall	Grand Ballroom 1	Grand Ballroom 2	Grand Ballroom 3	Harbour View 1	
Chairs	Ang Put Mayalen Zubia	Alecia Bellgrove Wei Zhang	Sitti Zayda Halun Patrick Martone	Jenny Fong Eloise Bennett	Sam Karpiniec Maria Gil	

1315	**Building a seaweed industry in Northern Norway, seasonality study and development of high value fractions** Caroline Haukeland	**The impact of substituting fat with Kappaphycus alvarezii gel on the quality of chicken patties** Wolnia Pindi	**Elevated CO2 ameliorates the negative effects of UV radiation in the red alga Pyropia yezoensis** John Beardall	**Healthy and bleached Halymenia floresii red alga: A microbiome assessment** Shareen A Abdul-Malik	**Development of iota-carrageenan/ alginate composite films using processed stone sludge as a hardening agent** Maria M. Gil	
1330	**Hanging gardens – do floating kelp farm communities resemble natural kelp forests?** Trine Bekkby	**Physical and proximate analysis of crackers fortified with red seaweed, Kappaphycus alvarezii** Adella Anding Aganduk	**Carbon use and calcification strategies in a diversity of fleshy and calcifying tropical algae across irradiance gradients on reefs of Little Cayman Island** Marguerite Koch-Rose	**Preferred macro-algal host-species of the two epiphytic dinoflagellates (Gambierdiscus and Ostreopsis) inhabiting Jeju Island** Wonho Yih	**Antivibrio compounds from Indonesia red seaweed Laurencia saitoi** Noer Kasanah	
1345	**Mechanistic simulations of Laminaria hyperborea in a dynamic landscape of light, temperature, and winter storms** Tim Szewczyk	**Characterisation of alginates and metal content of Australian brown seaweeds for food and biomedical applications** Alecia Bellgrove	**Seaweed farming offers an avenue toward greater food security and healthier diets in Malaysia** Adibi M Nor	**Microplastics in seaweed farming area in Takalar waters of South Sulawesi, Indonesia** Jamaluddin Fitrah Alam	**Gene expression modulation in atopic dermatitis and inhibition of Staphylococcus aureus adhesion by fucoidan** Sam Karpiniec	
1400	**DISCUSSION**	**DISCUSSION**	**Status and prospects of seaweed farming in the Sulu archipelago, SW Philippines** Sitti Zayda Halun	**DISCUSSION**	**DISCUSSION**	
1415-1420	**ROOM CHANGE**					

1420 – 1505	PLENARY SESSION #6	Federation Concert Hall
Prize Awards & Closing		
1420 – 1505	Prize Awards & Closing	

Saturday, 25th February 2023

POST-SYMPOSIUM TOURS	
DIVING	BOTANY ABOVE WATER: A GUIDED TOUR AT MOUNT FIELD NATIONAL PARK
Time: Group 1 – 06:45 – 16:30 (approx) Group 2 – 10:00 – 20:00 (approx) **Cost**: $370 AUD. The price includes transfers (approx 1 hour 15 minutes journey) packed lunch, 2 dives at different sites and full gear hire. Numbers are limited. **Departure**: Hobart Grand Chancellor **Return**: Hotel Grand Chancellor	**Time**: 08:30 – 16:30 **Cost**: $220pp AUD. **Departure**: Hobart Grand Chancellor – 08:30am pick up **Return**: Hobart Grand Chancellor – 16:30pm drop-off **Duration**: Approx. 8 hours

Posters

Poster Program

1A. APPLIED AND INDUSTRY – Phycolloids and Bioactives	
Poster Title	**Poster Author**
Dermatological potential of Codium sp. extracts and valorization of the residual biomass through an integrative biorefinery approach	Dr Celso Alves
How safe are the seaweeds on Australian supermarket shelves? – Food safety of imported seaweeds	Dr Cecilia Biancacci
Sequential extraction methodology for simultaneous recovery of phycobiliproteins and agar from Gracilaria chilensis	Dr Stephanie Brain-Isasi
Optimization of Phenolic Compound Extraction from Sargassum thunbergii by Subcritical Water	Professor Byung-Soo Chun
Physicochemical variations in sequentially extracted alginates from Ghanaian Sargassum fluitans and South African Ecklonia maxima	Miss Clarisa Naa Shormeh Darko
Developing algal functional foods by modifying carbohydrate & protein profiles to target lifestyle disorders	Radhika Dharap
Nutritional Supplement Blend of Seaweeds, Mushrooms, and Acai Berry to Complement Cancer Therapy	Mr Kevin Engholdt
Micropropagation of eucheumatoids using brown seaweed liquid extracts from Ascophyllum nodosum and Laminaria digitata	Dr Anicia Hurtado
Reversibility of sarcopenia by Ishige okamurae and its active derivative Diphloroethohydroxycarmalol: Aging rodent and human clinical study	Mr Jimin Hyun
Purification and Structural Characterization of Sulfated Polysaccharides Derived from Brown Algae, Sargassum binderi: Inhibitory Mechanism of iNOS and COX-2 Pathway Interaction	Mr Jun-Geon Je
Purification and characterization of a hemagglutinin from the red alga, Gracilariopsis chorda, from Japan	Prof. Hirotaka Kakita
Uronic acid and their oligomer microanalysis by normal-phase partition chromatography with fluorescence derivatization	Prof. Hirotaka Kakita
BlueBio MINERVA: Marine Innovation using Novel Enzymes for waste Reduction and Valorisation of Algal biomass	Dr Fanny Lalegerie
Characterization of Bioactive Compounds in Subcritical Water Extracts Obtained from Ecklonia stolonifera	Dr Hee-Jeong Lee
The antioxidant activity of Neutrase-assisted hydrolysate from heat-resistant Pyropia yezoensis by molecular weight change	Sang-Woon Lee
Asparagopsis armata: An invasive seaweed with a chemical arsenal useful in a plethora of industries	Prof. Marco Lemos
ORCHESTRA – Add-value to ORCHards through thE full valoriSaTion of macRoalgAe	Prof. Marco Lemos
Relevance of brown seaweed fucoidans as therapeutics for Type-2 diabetes mellitus (T2DM) and cancer progression	Dr Blessing Mabate
Cultivation, extraction, and purification of algal lectin from red marine alga Kappaphycus alvarezii	Ms Intan Mariana Maliki
Effects of abiotic factors and fragmentation on asparagopsis armata (Rhodophyta): Optimising conditions for bromoform production	Miss Stephanie Maresse

Poster Program

Fatty acid composition in different thallus structures of Macrocystis pyrifera present in ecoregion of Magellan	Mr Fabio Méndez
Mapping global seaweed farming potential to support climate and environmental benefits	Dr Monica Moritsch
Seasonal variation in seaweed diseases prevalence, growth and carrageenan of Kappaphycus and Eucheuma in Tanzania	Mr Msafiri Andrew Ndawala
Enzymatic extraction of phenolics and polysaccharides from brown seaweed and antioxidant activity of the extracts	Dr Hoang Chinh Nguyen
In Silico Approaches of Phytoconstituents from Caulerpa racemosa Microcapsules by Heat Effect	Dr Eko Nurcahya Dewi
Characteristics of Spray-Dried Powder with Various Wall Materials from Pyropia yezoensis Subcritical Water Hydrolysates	Dr Jin-Seok Park
Cooking and processing of seaweed to improve consumer acceptance, protein digestion and nutrient bioavailability	Dr Linda Samuelsson
Elucidation of food functionality of farmed Sargassum horneri for the purpose of global warming countermeasures	Prof. Akiko Taniguchi Yamada
Molecular docking study of Halymenia durvillei extract against VP26 Protein of White Spot Syndrome Virus	Dr Asmi Citra Malian A.R. Tasakka
Red seaweed derived bioactive ingredients improve animal health and productivity in shrimp, poultry and livestock	Dr Hemanth Giri Rao Vantharam Venkata
Planting seeds of clarity: Publication and development of the Australian Standard for Aquatic Plant Names	Gordon Yearsley
Cytokinin-like activities of some Rhodophyta species from tropical and subtropical waters	Dr Nair Yokoya
Effect of intake of mekabu (Undaria pinnatifida sporophylls) on blood pressure lowering and swelling improvement	Dr Kazuma Yoshizumi
Genome-scale protein interactome mapping to predict seaweed anti-cancer secreted peptides	Dr Min Zhao

1B. APPLIED AND INDUSTRY – Applications	
Poster Title	**Poster Author**
Sodium alginate film properties exhibited when the plasticiser is manipulated	Mr Luke Barnett
Characterization of bioplastics developed from Kappaphycus alvarezii crosslinked with commercial alginate	Miss Eunice Lua Hanry
Optimization of biomass to water ratio and glycerol content of bioplastics developed from Kappaphycus alvarezii	Miss Eunice Lua Hanry
Analysis of bromoform in Asparagopsis seaweed and downstream-processed feed additives; first NATA-accredited method in Australia	Dr Tim Jordan
Uptake of ammonium nitrogen in fish aquaculture wastewater by Japanese algal family Gracilariaceae	Prof. Hirotaka Kakita
From marine invader to shrimp aquaculture life saver: Asparagopsis armata extracts against Vibrio parahaemolyticus	Prof. Marco Lemos
Effects of food extruded with macroalgae meal on the development of sea urchin Loxechinus albus	Dr Andres Mansilla

Poster Program

Improvement of fermentable monosaccharides production from Ulva lactuca biomass as response to abiotic factors modulation	Dr Aline Martins
The overlooked potential of Pacific tropical seaweeds – an assessment of opportunities in New Caledonia	Dr Lydiane Mattio
Potash derived from rhodophytes (SAGAR Amrit) and its derivatives on the tuber yield and starch content of cassaca root Manihot esculenta Crntz	Dr Munisamy Shanmugam
Selection of marine algae for nutrient biofilter and bioproduct trials in the GBR coastal region	Miss Emma Theobald
An in vitro evaluation of seaweeds as future feeds for cattle	Ms Mirka Thorsteinsson

Poster Title	**Poster Author**
Ancestral and current uses of the Pyropia complex in southern Chile recommendations for its sustainability	Mrs Marcela Avila
Red algae (Rhodophyta) Sarcopeltis skottsbergii in the southern Chile: Current status and strategies for sustainability	Mrs Marcela Avila
Enhanced enzymatic-hydrolysis of Cladophora glomerata by freeze-drying of cellulase from Trichoderma viridae for bioethanol production	A/Prof. Kangsadan Boonprab
What do we mean by "sustainable seaweed"? Stakeholder perceptions of a 'sustainable' Australian seaweed industry	Ms Zoe Brittain, Ms Louise Cairney
Production of G. Changii microplantlets using Ascophyllum Marine Plant Extract Powder (AMPEP) as phycobiostimulant	Mrs Ida Capacio
Technology Verification on the Land and Sea-based Cultivation of Sargassum in the Philippines	Mrs Ida Capacio
Utilizing indigenous sustainable fishery resources that meet standards for human consumption of native seaweed	Ms Seaenna Correa-Garcia
Comparison of three culture methods of red seaweed in coastal waters off northern Sri Lanka	Prof. Mariyanuge Dileepa Samika Thanuksha De Croos
Seaweeds for a sustainable future – The Blue Food Center, Sweden	Dr Fredrik Gröndahl
Protocol to biomass production of the green seaweed Ulva ohnoi from germlings' clusters	Dr Leila Hayashi
A model experiment on discoloration and recovery of Pyropia suborbiculata	Dr Eun Kyoung Hwang
Potentially toxic elements in seaweed and how to extract them	Madeleine Jönsson
Cultivation of Tasmanian Caulerpa for food: A potential high-value seaweed product	Mr Micah Landon-lane
Learnings from Seaweed Farming in Ireland and potential of IMTA	Ms Aoife O Sullivan
SølKelp – North-South Seaweed Cultivation Partnership	Mrs Inês Oliveira
The effect of cultivation conditions on pigment content and net photosynthesis of Ceramium tenuicorne	A/Prof. Tiina Paalme

Poster Program

A calibrated growth model for optimising potential nutrient remediation of macroalgae IMTA in South-East Tasmania	Ms Tormey Reimer
Production and characterization of fucoidan-active enzymes from Lentimonas sp. CC4	Diego Reyes
Tropical Seaweed: Solution to the World	Ms Devi Setya Rini
Eucheuma isiforme cystocarps development at Yucatán coast, Mexico	Mr. Daniel Robledo Ramírez
Persistent marine bacteria isolated from a closed cultivation system in a culture of Kappaphycus alvarezii	Miss Rennielyn Rupert
Effects of temperature, irradiance, and nutrients on gametophyte growth and sporophyte production of Ecklonia radiata	Mr Jakop Schwoerbel
Land-based cultivation of Gracilaria cornea seaweeds for extraction of agar and skin-health promoting substances	Dr Eitan Solomon
Extending sea-based cultivation season of Ulva fenestrata by post-harvest treatment in herring production process waters	Mr Kristoffer Stedt
Differences of ontogenetic development, growth and biochemical profiles in early developmental stages of Ulva fenestrata	Dr Sophie Steinhagen
Bull kelp cultivation in Tasmania and New Zealand	A/Prof. Jeff Wright
Temperature as determinant factor on spontaneous generation of Kappaphycus alvarezii strains cultivated in subtropical waters	Dr Nair Yokoya
Aquaculture trial of endangered kelp Kjellmaniella crassifolia in eastern and southwestern coasts of Korea	Dr Hyun Il Yoo

2. ECOLOGY

Poster Title	**Poster Author**
Analysis of marine ecological information based on seabed topography	Prof. Chang Geun Choi
Habitat status and management plan of Silvetia siliquosa in Korea	Prof. Chang Geun Choi
Assessing Local Adaptation in Macroalgal Microbiomes	Miss Shauna Corr
A synthesis of hydrodynamics assessment methods for seaweed dominated shores	Miss Wendy Diruit
Shifts in macroalgae composition alters dissolved organic carbon flow in Baltic coastal ecosystems	Mr Jack Hall
Cost-effective methods to observe seaweed ecosystem for blue carbon study	Dr Ken-ichi Hayashizaki
Seascape factors are responsible for the genetic diversity and connectivity of Ecklonia cava populations	Seokwoo Hong
Effects of indole-3-acetic acid on algal growth of three kinds of Japanese algal family Gracilariaceae	Prof. Hirotaka Kakita
A proposed framework for quantifying regenerative effects of aquaculture in coastal ecosystems	Dr Janet Kubler
Mapping photosynthetic pigments in Antarctic coralline algae (Tethysphytum antarcticum) with hyperspectral imaging	Mr Juan Montes-Herrera

Poster Program

A Study on the Marine-Physics-Environment research of Marine Forests in the East Sea	Dr Youngkweon Lee
Water motion and seasonality in morphology of Lessonia corrugata	Mr Allyson Nardelli
Marine ecosystem restoration through creation of seagrass meadow	Mr Oh JC
Characteristics of marine algal community of intertidal zone in Yeongil Bay, East coast of Korea	Se Jeong Park
The effect of sedimentation on spore settlement and recruitment of the Arctic kelp, Laminaria solidungula	Mrs Jaide Phelps
Chemical composition of the three holopelagic taxa of Sargassum in the Mexican Caribbean: Ecological implications	Dr Daniel Robledo
Predicting habitat suitability for the red sea plume (Asparagopsis taxiformis) in the Great Barrier Reef	Miss Najeen Rula
Remote sensing for macroalgal blooms detection: Using a new index in Tuggerah Lakes, NSW, Australia	Dr Maria Schreider
Elucidating the effect of physical factors on the macroalgal communities over small spatial scales	Mr Shin-ichiro Tanimae
Seaweed community composition in Arikawa Bay, Nagasaki Japan may be related to minimum winter temperature	Mr Hiroto Tateishi
Attached Ulva meridionalis on nearshore dikes may pose a new ecological risk in the Yellow Sea	Zhangyi Xia

3. OCEAN CHANGE AND CLIMATE MITIGATION

Poster Title	Poster Author
The effects of Ocean Acidification on macroalgal communities in coastal areas of the Baltic Sea	Miss Gerli Albert
Structural profiling of fucoidans based on non-enzymatic hydrolysis and mass spectrometry	Miss Margot Bligh
Big Seaweed Search Mexico: Using citizen science to address global environmental challenges in the Caribbean	Prof. Juliet Brodie
Climate change threatens the distribution of Chilean kelps	Prof. Alejandra Gonzalez Vasquez
Chimerism improves higher-temperature tolerance in the Chilean kelps Lessonia spicata & L. berteroana	Prof. Alejandra Gonzalez Vasquez
Exploring the CO2 capture in the kelps L. spicata and L. beteroana from central Chile	Prof. Alejandra Gonzalez Vasquez
A novel approach to measure high throughput thermal tolerance using three canopy-forming kelp species over a latitudinal gradient	Miss Rosalie Harris
2022 Discoloration of Pyropia with the winter diatom bloom at culture farms of Haenam, Korea	Dr Jin Suk Heo
Quantifying Blue Carbon: Kelp contribution to carbon sequestration in marine sediments	Dr Robert Hickson
Effects of pH, temperature and light on carbon metabolism in Macrocystis pyrifera gametophytes	Ms Barbara Labbe

Poster Program

Carbon acquisition strategies of Tasmanian red seaweeds (Rhodophyta) and their sensitivity to [H+] and OA	Ms Barbara Labbe
The effects of intraspecific variation on forecasts of species range shifts under climate change	Jingjing Li
Aligning multiple driver research through the Multiple Environmental Driver Design Lab for Experiments (MEDDLE)	Dr Christina McGraw
Species-specific responses of benthic primary producers to the increasing CO_2 in the Baltic Sea	A/Prof. Liina Pajusalu
The effects of temperature on populations of the red alga Gracilaria caudata from Brazilian coast	Prof. Estela Plastino
Potential role of seaweeds in climate change mitigation	Mr Finnley Ross
Seaweed afforestation at large-scales exclusively for carbon sequestration: Critical assessment of risks, viability and the state of knowledge	Mr Finnley Ross
International stakeholder perspectives on implementing multiuse and integration of seaweed aquaculture with other sea uses	Dr Jean-Baptiste Thomas
Phycoforms – Building the future with seaweed	Mr Shimroth John Thomas

Poster Title	**Poster Author**
Temperature does not affect the rate of dissolved organic carbon (DOC) release by Ecklonia radiata	Miss Eloise Bennett
Comparative transcriptome analysis of wild-type and mutant strains of Pyropia yezoensis	Dr Jong-il Choi
Pyropia tenera (Bangiales) mutant with enhanced temperature tolerance	Dr Jong-il Choi
Nitrogen uptake by Sargassum siliquosum: Implications for integration into recirculated aquaculture systems	Miss Grace Edwards
Effect of macroalgal community succession on the ecophysiology of crustose coralline algae: A photophysiological perspective	Miss Ye Rim Kim, Prof. Young Sik Kim
Spatial variability of phlorotannins extracted from Hormosira banksii along a longitudinal gradient in Victoria (Australia)	Ms Flora Lam Kim
Cross-tolerance induction in Pyropia yezoensis to improve resistance to pathogenic oomycetes	Dr Ji Woong Lee
Photosynthetic activity and pigments composition of Adenocystis utricularis along a latitudinal gradient in Antarctic Peninsula	Mr Fabio Méndez
Season regulates flux of dissolved organic carbon from a temperate seaweed forest	Mrs Ellie Paine
Research progress on the CO_2 concentrating mechanism of Ulva sp.	Jingyi Sun
Allelopathic effects of macroalga Gracilaria salicornia on the regulation of growth and metabolism of Phaeodactylum tricornutum	Ligong Zou

5. TAXONOMY, DIVERSITY AND EVOLUTION

Poster Title	**Poster Author**
Occurrence of Asparagopsis taxiformis in Bulusan, Sorsogon Philippines: A new record	Mrs Ida Capacio, Dr. Anicia Hurtado

Poster Program

Uncovering the macroalgal flora of Rangitāhua/Kermadec islands (New Zealand)	Dr Roberta D'Archino
Unravelling cryptic diversity in Porolithon, one of the most important reef-building coralline algal genera	Guillermo Diaz-Pulido
Revealing microbiome diversity of natural phytoplankton communities	Dr Cintia Iha
Developing a DNA barcoding framework for a coral larvae super inducer, the coralline alga Titanoderma	Mr Timothy Jackson
Diversity of Macroalgae at the Intertidal Zones in the Selected Islands in Antique, Philippines Based on Habitat Characteristics and Survey of Molecular Sequences Available on Online Databases	Ms Niccie Rosietess Madarcos
Understanding the influence of genetic and environmental factors on growth and anti-methanogenic activity of Asparagopsis	Ms Asri Pratitis

Dermatological potential of Codium sp. extracts and valorization of the residual biomass through an integrative biorefinery approach

Celso Alves[1], *, Joana Silva[1], Alice Martins[1], Roberto Clerque[1], Rita M.M. Santos[2], Ana S. Mestre[2], Ana P. Carvalho[2], Márcia I. Goettert[3], Rui Pedrosa[1], Marco F.L. Lemos[1],*

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Due to the growing awareness of skin health, there is a massive demand for new and natural skincare products. Seaweeds have revealed to be a rich source of bioactive compounds with relevant biological properties for dermatological applications. However, after the extraction of bioactive ingredients, the residual biomass corresponds to ca. 99% of the seaweed original weight and maintains its lignocellulosic structure, being still a valuable resource for a broad range of applications. Therefore, this study aimed to develop a sustainable biorefinery process by evaluating the dermatological potential of five extracts obtained from the green seaweed Codium sp., together with the transformation of its residual biomass into biochars. Five independent extracts: water (F1), ethanol: water (F2), ethanol (F3), n-hexane (F4), and ethyl acetate (F5) were obtained, and their antioxidant (DPPH, FRAP, ORAC, TPC), anti-enzymatic (hyaluronidase, collagenase, elastase), cytotoxicity, and anti-inflammatory properties were evaluated. Regarding the antioxidant capacity, the F3 exhibited the highest values of total phenolic content (1.10±0.09 mg EAG/g extract) and FRAP (1.83±0.05 μM $FeSO_4$/g extract), while the and ethyl acetate fraction (F5) exhibited the highest value of ORAC (2,109.30±34.80 μmol Trolox/g extract). This fraction also exhibited the best anti-enzymatic capacity, inhibiting the activity of elastase around 88% at 200 μg/mL. On the other hand, F2 and F3 fractions displayed the highest anti-inflammatory activity significantly reducing the TNF-α release induced by LPS treatment in human whole blood. Biochars were obtained by conventional thermal carbonization of F2 residual biomass in inert atmosphere (TC) and by advanced processes such as hydrothermal carbonization (HTC) and acid-mediated carbonization (AMC). It has an ash content of 27%, which after TC attains 50 % but decreases for advanced carbonization processes (14% for HTC and 9% for AMC). The ashes contain NaCl, KCl and $CaCO_3$. The increase of ash content during TC justifies the higher yield of this procedure (44% versus 24% for HTC and 19% for AMC). The biochar synthesized by HTC has the highest surface area and total pore volume (15 m^2/g and 0.034 cm^3/g). Data available reveal that the biochars obtained by TC and HTC present 57-62% C and 18-25% O with relevant amount of N (11-14%). The green seaweed Codium sp. extracts possess great potential, while through an integrative biorefinery approach the whole biomass may be used, increasing this biomass value.

Poster Abstracts in Program

How safe are the seaweeds on Australian supermarket shelves? - Food safety of imported seaweeds.

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While the health benefits associated with seaweed consumption are numerous, concerns exist associated with possible adverse effects of regularly consuming seaweeds due to potentially high content of heavy metals, arsenic, and iodine. Seaweeds are becoming easily available in supermarkets and groceries stores in Western countries, but in Australia they are almost entirely imported from Asia. Whilst Food Standards Australia and New Zealand (FSANZ) regulates the safety of imported food products, seaweed-specific guidelines exist for arsenic and iodine only and regular testing is not required. We analysed the mineral and metal content of three or four (yakinori) different brands of five commonly imported seaweed products from various Asian countries: kombu, wakame, yakinori sushi sheets, Korean seasoned laver and seaweed crackers. The samples were ground, homogenized, and quantified in triplicate using ICP-MS. Results indicate that levels of Mn, Se, Mo, Cd and Sr may pose a risk to consumers. Iodine content in all kombu samples exceeded the FSANZ tolerable content of iodine for dried seaweed products (1000 mg/kg dry weight), and some brands of yakinori and wakame surpassed the tolerable daily intake of 150 µg iodine/day recommended by the European Food Safety Authority (EFSA); thus all may pose a risk to consumers. Increased monitoring of commercially available seaweed products is desirable to increase data of potential contamination to support further development of regulations on maximum limits and intake recommendations. Furthermore, these results should encourage further exploration into whether 'home-grown' Australian seaweeds produced in our unpolluted waters could provide safer food products.

Poster Abstracts in Program

Sequential extraction methodology for simultaneous recovery of phycobiliproteins and agar from *Gracilaria chilensis*

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The red alga *Gracilaria chilensis* C. J. Bird, McLachlan & E. C. Oliveira (*Agarophyton chilense* Gurgel, J.N.Norris & Fredericq) is one of the few algae commercially farmed in Chile, where this alga is commonly named “Pelillo”. Its main by-product is agar, a gelling agent used in the food and pharmaceutical industries. This alga is also a valuable feedstock for the biorefinery of phycobiliproteins (PBPs), coloured and fluorescent water-soluble proteins with industrial applications.

This work aimed to valorise *G. chilensis* by sequentially extracting PBPs and agar. After freeze-thaw treatment, we extracted two PBPs: R-phycoerythrin (R-PE) and R-phycocyanin (R-PC). After two purification steps, we recovered both PBPs from crude extract (R-PE = 0.20 mg/g DW and R-PC = 0.23 mg/g DW) with a purity index >2, making them suitable for food applications. After PBPs extraction, we recovered agar from the residual algal matter.

There were no significant differences between the physical parameters of agars obtained after PBP extraction and those from agars directly extracted from *G. chilensis* (melting and gelling temperature, and agar deformation). The agar yield after PBPs extraction was 24.9±1.0 % and showed gel strength of 726±182.9 g/cm^2, whereas agar directly extracted from alga yielded 23.1±2.0 % with gel strength of 730.5±96.9 g/cm^2. The agar obtained after PBPs extraction allowed the microbial growth and the effective separation of nucleic acids, resulting in a low-cost alternative for DNA electrophoresis without agarose purification.

Our results demonstrate that the method proposed allowed the simultaneous extraction of PBPs and agar from *G. chilensis*.

Optimization of Phenolic Compound Extraction from *Sargassum thunbergii* by Subcritical Water

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Sargassum thunbergii is a brown seaweed rich in functional polysaccharides and phenolic compounds. In this study, the optimal Subcritical Water Extraction (SWE) conditions for antioxidants and polyphenols of *S. thunbergii* were evaluated using Response Surface Methodology (RSM). The optimal extraction conditions were determined to be 196.37 °C, 31.58 min, 3.42 Mpa. The total phenolic content (TPC) was predicted to be 16.023 mg PGE/g of dry sample, The TPC of the optimal condition *S. thunbergii* extract was 17.08±0.28 PGE/g, confirming that it was a statistically significant model. The antioxidant activity for ABTS, DPPH radical scavenging, FRAP and Reducing power of *S. thunbergii* extract was (51.67±0.64, 32.38±0.78, 35.10±1.73, 28.69±0.58) mg TE/g dried sample, respectively. Finally, individual phenolic compounds present in the extracted bioactive compounds from *S. thunbergii* was analyzed by HPLC. The result of this study is *S. thunbergii* could be extracted using subcritical water process, which is not only more environmentally friendly but also more effective to make functional substance. And this study provides scientific evidence for further exploitation and utilization of *S. thunbergii* in the preparation of functional foods as well as in medicine, cosmetics, and the development of active films.

Poster Abstracts in Program

Physicochemical variations in sequentially extracted alginates from Ghanaian *Sargassum fluitans* and South African *Ecklonia maxima*

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Alginates extracted from two brown seaweeds, *Ecklonia maxima and Sargassum fluitans* sourced from the Atlantic Ocean along the southern and western coasts of Africa, respectively, are assessed for variations in their physicochemical characteristics. Three different fractions of alginate from each substrate were extracted for this study via a sequential extraction procedure. The first fractions (F1) of both species were extracted at room temperature whereas the last two sets (F2 and F3) were at higher temperatures. Fraction three (F3) from *E. maxima* yielded the highest alginate, about ~59% more than *Sargassum fluitans*. The molecular weight of the first fractions (F1) in both substrates were the highest (MW > 400 kDa) with the least recorded as 44 kDa for F3 from E. maxima. Monosaccharide compositions of the fractions analyzed using HPLC-PAD were similar but of relatively different molar ratios. FTIR analyses on all six fractions from both species showed broad bands around ~1027 cm-1 and 1100 cm-1 which are indicative of the -OH bending of guluronic and mannuronic acid units, respectively. Fractions from *Sargassum fluitans* recorded least M/G values from the 1H NMR analysis conducted on fractions of both species. The present study shows that the Ghanaian *Sargassum fluitans* yields notably brittle gels compared to the highly elastic alginate extracted from the South African *Ecklonia maxima*. This reported varying physicochemical properties provides an evidence for the potential suitability of these phycocolloids for either high or low gel-strength applications.

Developing algal functional foods by modifying carbohydrate & protein profiles to target lifestyle disorders.

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Non communicable diseases (NCDs) are global burden affecting 41 million people worldwide. NCDs affect both genders as manifestations due to behavioral habits, environmental, physiological, genetic factors in all age groups. Unhealthy diets are one of the major reasons for conditions like diabetes, hypertension, obesity, CVD etc. Ultra-processed foods derive their popularity from its palatability, increased shelf-life, convenience and are expected to increase in demand. This emphasizes the need for interventions by introducing nutrivalent foods to tackle the inconspicuous pandemic.

Through this paper, we accentuate on counteracting the ill effects of ultra-processed foods by utilizing cyanobacteria and seaweeds. *Spirulina platensis* functions not only as nutrient rich protein food but also imparts antioxidative, antiallergic, anti-inflammatory effects. Seaweeds have a long history of human consumption and is a part of regular South Asian cuisines. In this study, a novel formulation of popular processed foods containing whipped cream, ice-creams, cookies etc. using algae has been attempted to explore it as functional food to target lifestyle disorders and evaluate its ameliorative potentials by modifying carbohydrate profile. Based on our findings, using algal extracts, sugar alternative blend exhibits physiological effect that can be attributed to the presence of numerous bioactive constituents in the formulation. The protein signatures also reiterate the presence of various protein constituents, higher in quantity and better quality when compared to those available in the market. These formulated products emerge out as a potential candidate for functional food with its biochemical properties and sensory perceptions are elucidated in this study.

Poster Abstracts in Program

Nutritional Supplement Blend of Seaweeds, Mushrooms, and Acai Berry to Complement Cancer Therapy

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The products from Infinitum Health portfolio have garnered dramatic results from consumers causing an intense public demand. One of their flagship products, Infinimin®, has collected numerous positive testimonials from patients with diverse health problems. The most common testimonies involve cancers and based upon these testimonials, a preclinical study using four cancer cell lines was performed. To understand more about the mechanisms by which these customers are stating benefits, we designed an MTT Screening Assay using four cancer cell lines to aid in understanding cell viability and apoptosis. The effects of Infinimin® on cancer cell viability was tested on the following 4 cell lines; A-172, glioblastoma; A-375, malignant melanoma; A-549, lung; and DU-145, prostate. The test product was prepared for addition to cell cultures in vitro in the following manner; 0.5g dry product was added to 5ml of phosphate-buffered saline (PBS) and 0.5g dry product was added to 5mL 95% ethanol (EtOH). Statistically significant reductions (p: <.05) of cell viability were seen for all 4 cancer cell lines following treatment with Infinimin® (PBS). The decrease in Glioblastoma and Prostate Carcinoma cell viability following treatment with Infinimin® (PBS) was dose-dependent and extended across a broad dose range. This is a first step understanding how consumption of Infinimin® supports health. In the case of cancers, the data here suggest that some compounds in Infinimin® could have a direct synergistic effect on reducing the growth of cancer cells. Moreover, the consumption of Inifinimin® may also support the defense and anti-cancer properties of the immune system. Based on the ingredients in Infinimin®, particularly three seaweed species, three mushroom species, acai berry, and a base multivitamin panel, we would expect to see immune activating effects but not as broad as impacting four different cancer physiologies. As shown, there are no toxic effects with this product, however, further research is needed in the preclinical space as well as clinical trials to validate efficacy and understanding of the mechanism of action of these extracts and how they are reducing cancer growth.

Poster Abstracts in Program

Micropropagation of eucheumatoids using brown seaweed liquid extracts from *Ascophyllum nodosum* and *Laminaria digitata*

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Eucheuma denticulatum and *Kappaphycus alvarezii* are two commercially important, cultivated carrageenophytes in Southeast Asia. Large-scale farming of these seaweeds through repeated vegetative propagation and virtual monocropping has resulted in various phyconomic issues. The efficacy of commercial liquid extracts from the brown seaweeds *Ascophyllum nodosum* (ANE) and *Laminaria digitata* (LDE) on the direct formation of axes and survival of these two eucheumatoids were examined using tissue culture techniques. Seaweed apical sections (3–5 mm long) were cultured for 45 days at different concentrations of ANE and LDE (i.e., 0.01, 0.1, 1.0, 3.0, 5.0 mL $2L^{-1}$), and control (UV-filtered seawater). Results revealed that between the two seaweed liquid extracts, LDE provided better overall performance for *E. denticulatum* and *K. alvarezii* in tissue culture. The present study recommends the use of 0.1 mL LDE $2L^{-1}$ for optimum results for the tissue culture of *E. denticulatum*, given the high percent survival (95.3 ± 0.9%), percent formation of direct axes (95.3 ± 0.9%), and their longest length (10.0 ± 0.3 mm) at the end of a typical 45-day culture period, as well as the highest percentage formation of axes at day 14 (88.0 ± 4.9%). 1 mL LDE $2L^{-1}$ is recommended in tissue culture of *K. alvarezii*. Given the effects on survival and direct axes formation and length were different, interpretations should be made with caution. Additional experiments for *K. alvarezii* are necessary to ensure reproducibility of results in order to confirm the optimum concentration of ANE or LDE that can be applied for mass production of plantlets for out planting purposes. Some of these additional data will be discussed in the presentation.

Poster Abstracts in Program

Reversibility of sarcopenia by *Ishige okamurae* and its active derivative Diphloroethohydroxycarmalol: aging rodent and human clinical study

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With the rapid increase in the elderly population worldwide, the number of people with sarcopenia has also increased significantly, and this disease is emerging as a medical and social issue. The development of pharmaceutics targeting sarcopenia is limited owing to the occurrence of side effects, and exercise therapy also has a limited scope of application. Therefore, it is necessary to develop safe and biocompatible agents to treat age-related sarcopenia. *Ishige okamurae* (IO), an edible brown alga, and its active substance, diphloroethohydroxycarmalol (DPHC), have been reported to have various physiological functions, including skeletal muscle regeneration ability. However, this effect has not been verified in an *in vivo* aging model. As an aging model, the oral IO extracts and DPHC supplemented 14-month-old female C57BL/6J mice were compared to the young group in this study; the mice model showed a substantial restoration of physical exercise ability with the imbalance of famine hormone and senescence-associated secretary phenotypes compared with those in young mice. Regarding the lean mass increase in aging mice following IO extract and DPHC administration, the muscular characteristics and molecular alterations in the gastrocnemius and soleus muscles, which are sensitive to the damage that occurs during the aging process, were significantly improved. Interestingly, the improved physical performance and androgen hormone imbalance, and enhanced gastrocnemius muscular characteristics were reproduced in 12-month-old aging male mice. In addition, the clinical trial (Age: 50-85, period: 12-weeks) showed a significant increase in quadriceps muscle strength (right) was observed in IO extract treatment group via ITT and PP analysis, and no hazards were found in safety assessment for participants. Collectively, the current study reveals that the natural agent IO extract and its derivative DPHC can reverse sarcopenia that occurs during the process of aging by improving the imbalance of muscle regeneration *in vivo*.

Purification and Structural Characterization of Sulfated Polysaccharides Derived from Brown Algae, *Sargassum binderi*: Inhibitory Mechanism of iNOS and COX-2 Pathway Interaction

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In this study we purified and structurally characterized sulfated polysaccharides from brown algae, *Sargassum binderi* (*S. binderi*, SBPs), and evaluated their biological activity in vitro and in vivo. SBPs, Fraction 4 (SBP-F4) by DEAE, with an average molecular weight of 2.867× 10^4 g/mol, had the highest polysaccharide and sulfate content (75.15±0.25% and 24.08±0.18%, respectively). The biological activities of SBP-F4 were investigated further in vitro and in vivo. Our results showed that SBP-F4 significantly suppressed the expression of inducible nitric oxide synthase (iNOS) and cyclooxygenase-2 (COX-2) proteins in LPS-activated macrophages. Moreover, in the LPS-treated zebrafish model, a significant decrease in cell death and NO production was observed. Collectively, these results showed that SBPs not only exert protective effects against LPS-induced cytotoxicity but also inhibit macrophage activation and their anti-inflammatory activity. Therefore, polysaccharides derived from *S. binderi* are potential anti-inflammatory agents for use in clinical settings.

Purification and characterization of a hemagglutinin from the red alga, *Gracilariopsis* chorda, from Japan

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Hemagglutinins (Protein-based ones are called lectins) are natural bioactive substances, which possess specific carbohydrate binding abilities. Four purified hemagglutinins in Japanese *Gracilaria vermiculophylla* have already been reported in detail. However, a purified hemagglutinin from *Gracilariopsis chorda*, which belongs to the same algal family *Gracilariaceae* as *Gracilaria vermiculophylla*, has not been reported in detail. Thus, in this study, we carried out purification and characterization of a hemagglutinin in the red alga, *Gracilariopsis chorda*. Ammonium sulfate concentration and standing time in the salting-out process were optimized to obtain hemagglutinin fractions with high specific activity. The combination first salting-out with 35% saturation for 1 hour and second salting-out with 70% saturation for 18 hour was most effective. A hemagglutinin was purified from an ammonium sulfate precipitation by ion exchange and gel filtration chromatographies. The *Gracilariopsis chorda* hemagglutinin contained large amounts of hexose and sulfate along with a small amount of protein. It agglutinated rabbit erythrocytes and had no divalent cation requirement for hemagglutination. The hemagglutinating activity was inhibited by complex-type glycoproteins, such as asialofetuin, fetuin and thyroglobulin, but was not inhibited by any of the monosaccharides tested. The results suggested that the *Gracilariopsis chorda* hemagglutinin was different from terrestrial organisms reported to date. The specific activity of the *Gracilariopsis chorda* hemagglutinin was higher than that of the high molecular weight *Gracilaria vermiculophylla* hemagglutin (H-GVH). Thus, and as with *Gracilaria vermiculophylla*, *Gracilariopsis chorda* seems to be a suitable source of industrially useful hemagglutinins.

Uronic acid and their oligomer microanalysis by normal-phase partition chromatography with fluorescence derivatization

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Algal alginates which consist of two uronic acids (i.e. D-mannuronate and L-guluronate) are important resources for a lot of industrial materials. The exact content of uronic acids and their oligomers is often an important feature in the study of their functional or biological properties. Uronic acid composition also influences the physical properties of polysaccharide preparations and gels in industry. Furthermore, the influences of the percentage and configuration of each uronic acid oligomer on biological and physiochemical properties of polysaccharides have also been reported. Therefore, a highly sensitive analytical technique for uronic acids and their oligomers would be useful for both biological studies and manufacturers' quality control. The aim of this study was to develop a method for microanalysis of uronic acids and their oligomers in normal-phase partition chromatography (NPPC), with postcolumn fluorescence derivatization. NPPC columns were evaluated to determine a suitable column for the microanalysis. HPLC and fluorescence derivatization conditions were optimized for uronic acid microanalysis. Fluorescence measurement was performed at 288 nm for excitation and 470 nm for emission. A linear gradient elution system was found to be a suitable method for the simultaneous microanalysis of uronic acids and their oligomers. The proposed method was successfully applied to uronic acid composition microanalysis. The present method seems to be a useful for microanalysis of uronic acids and their oligomers.

Poster Abstracts in Program

BlueBio MINERVA: Marine Innovation using Novel Enzymes for waste Reduction and Valorisation of Algal biomass

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Despite their occurrence across oceans worldwide and their recognised importance as a source of valuable molecules for industry, marine macroalgae remain an underutilised resource. With a significant and growing interest and investment across Europe, there are increasing opportunities to unlock the full potential of macroalgae. However, to be sustainable, any future intensified seaweed industry needs to be resource efficient, consider diversification and valorisation of biomass, and reduce waste. The BlueBio Cofund project MINERVA (‘*Marine Innovation using Novel Enzymes for waste Reduction and Valorisation of Algal Biomass*’) therefore aims to support sustainable and efficient exploitation of algal biomass across several industry sectors, using a biorefinery approach. By promoting exchanges between academia and the algal industry, developing new environmentally friendly processes that generate novel high-value products, and reducing biomass waste during harvesting and processing, MINERVA contributes to European macroalgal research within the framework of a Circular Blue Bioeconomy. Through the joint efforts of different partners from Ireland, Iceland and Sweden, the project uses omics-based approaches to generate new enzymes to treat biomass and develop new algal products for food, aquaculture, cosmetics, and biomedicine industries. Particular emphasis is given to polysaccharides, protein and phenolic contents for their antioxidant, antimicrobial, antifouling activities and/or particular physicochemical properties. With sustainability as an underpinning core principle, preliminary results feature optimised extraction processes; algal cell-wall biodegradation potential of bacterial isolates and clones obtained from brown seaweeds; and finally, evaluation of seaweed fibers and components for the food and aquaculture industries.

Poster Abstracts in Program

Characterization of Bioactive Compounds in Subcritical Water Extracts Obtained from *Ecklonia stolonifera*

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Recently, functional foods have gained much attention from the public owing to improving the healthy life and reducing the risk of diseases. *Ecklonia stolonifera*, a brown seaweed, has been recognized as a potential source of polyphenols for manufacturing functional foods because of its excellent anti-diabetic, anti-arteriosclerosis and outstanding liver protection capability from toxins. *E. stolonifera* was treated with subcritical water extraction (SWE) at five extraction temperatures (120°C to 220°C) and the pressure of 30 bar for 30 min. 50 mg/mL of dried powder sample was taken as a solid to liquid ratio. Methanol extraction was used as a standard to compare to the SWE method. Physicochemical properties of SWE were analyzed to get total phenolic, total flavonoid, total sugar and reducing sugar contents. Subcritical water extracts of *E. stolonifera* exhibit excellent antioxidant activity from various tests such as DPPH, ABTS+ and FRAP. The highest amounts of antioxidant activity for ABTS+ (35.98±0.18 mg TE/g), DPPH radical scavenging (38.18±0.59 mg TE/g) and FRAP (25.29±0.37 mg TE/g) were recorded at 195 °C. The maximum amounts were observed at 195°C for phenolics (26.02±0.06 mg TA/g) and flavonoids (8.40±0.21 mg catechin/g). The highest total sugar (102.04 ± 0.92 mg glucose/g) was reported at 120 °C, and the highest reducing sugar (61.82±1.41 mg glucose/g) reported at 170 °C, followed by 61.54 ± 2.10 mg glucose/g at 195℃. Based on this study, *E. stolonifera* treated with SWE method demonstrates promising properties for new healthy functional foods.

Poster Abstracts in Program

The antioxidant activity of Neutrase-assisted hydrolysate from heat-resistant *Pyropia yezoensis* by molecular weight change

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Pyropia yezoensis (PY) is species of red algae that is consumed a lot as food as well as has gradually decreased production, due to the impact of climate change. Based on this background, heat-resistant PY (HrP) has been developed, whereas comparative studies on HrP and commercial PY are still lacking. In this study, we investigated the antioxidant properties of HrP. HrP water extract showed a superior ROS scavenging effect against DPPH, alkyl, and hydroxyl radicals compared to the commercial PY water extract. Afterward, HrP was enzymatically hydrolyzed using seven-chosen enzymes (Alcalase, Celluclast, Flavourzyme, Neutrase, Protamex, Ultraflo, and Viscozyme) and these enzyme-assisted HrP hydrolysates (EHrPs) were evaluated the free radicals scavenging activity. Among them, Neutrase-assisted Hrp hydrolysate (NHrP) showed the highest protein content with antioxidant properties. NHrP was further evaluated for the molecular weights dependent antioxidant effect using the molecular weight cut-off system. membrane-passed fraction (10B; ≤10 kDa) emerged the outstanding antioxidant activity than an un-passed fraction (10A; >10 kDa) in ROS scavenging against H_2O_2, DPPH. Moreover, 10B treatment ameliorated H_2O_2-induced oxidative stress in Vero cells and zebrafish embryos (increased survival percentage and decreased cell death, and ROS formation). These data suggest that HrP might be capable of a potential antioxidant agent for nutraceutical industries.

Asparagopsis armata: an invasive seaweed with a chemical arsenal useful in a plethora of industries

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Researchers and stakeholders have begun to pay more attention to marine natural products, since they have been shown to be efficient and sustainable alternatives for many different applications in different industries. Seaweeds in general, and invasive seaweeds in particular, are important biomass sources to investigate among marine biomass. Originally from New Zealand, *Asparagopsis armata* (Harvey, 1855) is an invasive red seaweed that has spread abundantly over Europe. As they develop quicker and compete for resources, its existence poses an environmental stress for nearby populations. As a result, there are negative environmental and economic consequences.

This seaweed has been shown to produce several metabolites, such as sulphated polysaccharides, bioactive small molecular weight carbohydrates, bioactive peptides, bioactive lipids and halogenated volatile organic compounds. These have been shown to possess a myriad of bioactivities, such as antimicrobial, antioxidant, antitumor, anti-inflammatory, antifouling and antimethanogenic activity; however, there is still plenty of work to be done regarding many of the potentially interested target industries.

In this work, we report a summary of the complete study of *A. armata's* biotechnological potential, ranging from the manufacturing of 4 industry-friendly extracts (compatible with a biorefinery, sequential extraction approach), to their chemical characterization, to their bioactivity profiling with relevance for the food, feed, additives, nutraceutical, cosmeceutical, agricultural and pharmaceutical industries. Thus, a highlight of chemical composition and antibacterial, anti-yeast, anti-filamentous fungi, antioxidant, antienzymatic and cellular effects (cytotoxicity, photoprotection, anti-inflammatory and pro-healing) activities is presented.

Poster Abstracts in Program

ORCHESTRA - Add-value to ORCHards through thE full valoriSaTion of macRoalgAe

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The Fruit Sector is an important part of the European Agroindustry, accounting for 14% of the value of the EU agricultural production. Due the continuous growth of the global population and the limited global cropland, it is crucial to guarantee food safety and for all. To achieve that, the reduction of crop loss from pest origin and provide plant resistance to external factors is mandatory, while assuring fruit extended shelf-life during storage and distribution chain. This is nowadays guaranteed by synthetic compounds, that have ultimately been pointed as risk factors for the environment and public health, while also reducing fruit nutrient quality.

Since early times, seaweeds have been used in agriculture to fertilize the fields and augment plant productivity. Nowadays, the commercial production and exploitation of seaweed specific compounds with biotechnological relevance, as microbicides, biofertilizers, soil conditioners, among others, has been increasingly explored.

Among macroalgae, invasive species are widely recognized as a global threat for marine ecosystems equilibrium, causing serious economic and environmental negative impacts. The use of these invasive seaweed to obtain valuable bioproducts for agriculture will not only contribute to the creation of sustainable added-value products but also to the mitigation of the negative impacts caused by alien species, restoring the marine ecosystem integrity and sustainability.

ORCHESTRA project main goal is, this way, to add-value to invasive seaweed through a circular economy biorefinery pipeline, while providing solutions to pear and apple cultivars, improving the value chain, with sustainable, eco-efficient, and socially responsible practices, and in this work the opportunity for the use of several seaweeds in the orchard will be explored.

Relevance of brown seaweed fucoidans as therapeutics for Type-2 diabetes mellitus (T2DM) and cancer progression

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Fucoidans are sulphated polysaccharides derived from brown seaweeds, consisting of considerable proportions of *L*-fucose and other monosaccharides. The search for novel natural compounds as potential drugs, due to the side effects associated with some currently available synthetic drugs, has led to an extensive study of fucoidans. Fucoidans are reported to display several bioactivities, including anti-diabetic and anti-cancer properties. Our study sought to investigate the anti-diabetic (*viz*., inhibition of amylolytic enzymes) and anti-cancer activities of fucoidan. Firstly, fucoidans were hot water extracted from *Ecklonia maxima*, *Ecklonia radiata* and *Sargassum elegans*. These fucoidans were structurally and chemically profiled using FTIR, NMR, HPLC and colourimetric assays. Thereafter, the fucoidans were investigated for their anti-diabetic and anti-cancer activities. Our results show that fucoidans extracted from South African seaweeds inhibit α-glucosidase, with the most potent fucoidan exhibiting an IC50 of 19 µg/ml, compared to acarbose (a commercial anti-diabetic drug) with an IC_{50} of 332 µg/ml. Interestingly, fucoidans and acarbose also synergistically inhibited this enzyme, which enabled a remedial combination approach in a proposed new strategy to control Type-2 diabetes mellitus (T2DM). This combination strategy may reduce the amount of acarbose used and, therefore, the associated side effects. The fucoidans also exhibited anti-cancer activities - including inhibiting cancer cell adhesion to surfaces, anti-spheroid migration and anti-colony formation properties using a HCT116 human colorectal cancer cell line. In summary, fucoidans are seaweed polysaccharides that show potential application in alleviating T2DM and cancer progression.

Poster Abstracts in Program

Cultivation, extraction, and purification of algal lectin from red marine alga *Kappaphycus alvarezii*

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Numerous red algae species possess lectins with carbohydrate specificity towards complex glycoproteins or high-mannose *N-glycans*, eliciting biochemical responses such as antiviral, anticancer, and antibacterial activity, making them appealing tools in biomedical research. *Kappaphycus alvarezii*, a marine red alga, was collected from the coast of Semporna, Sabah, Malaysia. The collected sample was further cultivated in the Biotechnology Research Institute, Universiti Malaysia Sabah, in filtered seawater and with Provasoli's solution as its nutrient media, with pH 8.60-8.80 and salinity between 35-45 ppt. The crude protein from *K. alvarezii* was extracted by incubating it in a phosphate buffered saline (PBS) buffer, pH 7.0, overnight at 4oC. The sample was then homogenized in PBS buffer and precipitated to 85% using ammonium sulfate precipitation. The extracted crude protein was separated on SDS-PAGE with b-mercaptoethanol to detect the presence of putative lectin on the gel with an expected band size before being purified using a GalNAc-specific column. The purification was performed on a Sepharose 6B~GalNAc affinity column, and the peak appeared following the addition of elution buffer (0.85% NaCl with lactose). Hemagglutination assay performed on peak fractions capable of agglutinating mice erythrocytes treated with papain, showing probable lectin activity of the purified protein.

Poster Abstracts in Program

Effects of abiotic factors and fragmentation on *Asparagopsis armata* (Rhodophyta): Optimising conditions for bromoform production.

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The red alga *Asparagopsis armata* produces secondary metabolites (bromoform) that, when fed in small amounts to cattle and sheep, reduce enteric methane emissions by up to 98%, and thus, present an opportunity for mass cultivation of natural bromoforms. This study aimed to determine the optimal abiotic conditions for cultivation through three experiments 1) the interactive effects of light and initial biomass, 2) the interactive effects of nutrients, light and temperature, and 3) the effect of different degrees of fragmentation on growth of *A.armata* and contaminant algae, and the concentration and net production of bromoforms. Light strongly increased biomass and bromoform production in A. armata averaging 1.9 g FW/l/week1 and 44.9 mg/l/week^{-1} for biomass and bromoform production, respectively. Algae growth was further enhanced by the combined effects high light and high nutrient conditions, however growth of the small brown algae *Hincksia sandriania* was also very high under those conditions (up to 50-60%). Contamination was lowest in low light (30-50 µmol photons m^{-1} s^{-1}) and low nutrients (F10) treatments, although growth and bromoform production was also lower in those conditions (0.7-1.8 g/l/week^{-1} and 9.9-39.1 mg DW/l/week^{-1}, respectively). Fragmenting tetrasporophytes increased biomass and bromoform production. Notably, tetrasporophytes that were cut 8- or 16-times had ~ 1.6 times the biomass and 3-3.5 times the bromoform production compared to tetrasporophytes cut zero times. Overall, these results suggest light, and fragmentation can be manipulated to upscale growth and bromoform production, hereby providing a strong foundation to develop an industry protocol to cultivation of *A.armata* tetrasporophytes.

Poster Abstracts in Program

Fatty acid composition in the different thallus structures of the species *Macrocystis pyrifera* (L. C. Agardh) present in the sub-Antarctic ecoregion of Magellan

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The sub-Antarctic ecoregion of Magellan, a biogeographic area located in the southern South American continent, is unique in the world. This has no latitudinal replicas and presents a considerable environmental heterogeneity. Marine flora highlight with high endemism and the largest reserves of marine forests of brown macroalgae. Brown macroalgae have a great dominance along the coast. These are considered ecosystem engineers, because they provide and maintain shelter, feeding and reproduction sites for different species of biological and commercial importance. In addition, they have an important content of lipids, amino acids and fibers for both the food industry and biomedicine, being essential components to combat prevalent pathologies in the population. The aim was to determine the fatty acid content in the different thallus structures (holdfast, stipe and frond) of *Macrocystis pyrifera*. Individuals were collected in Rinconada Bulnes (53°35'47.76" S; 70°56'08.52" W) during spring 2021. Lipid extraction and fatty acid reading with gas chromatography was performed at the Faculty of Sciences, Universidad de Magallanes. Total lipid content showed higher values for stipe (3.73%) and frond (2.74%). The fatty acid profile showed higher values of monounsaturated fatty acids in stipe (Σ 44.7%) and holdfast (Σ 43.2%), while higher values of polyunsaturated fatty acids were observed in frond (Σ 32.9%). To know how Oleic acid (stipe and holdfast) and Linolenic and Eicosapentanoic acids (frond) are distributed in different structures of the thallus of *M. pyrifera*, allows us to know the nutritional and biomedical contribution.

Poster Abstracts in Program

Mapping global seaweed farming potential to support climate and environmental benefits

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There is an urgent need to remove carbon dioxide from the atmosphere, reduce greenhouse gas emissions, produce food, restore fisheries, and improve conditions of marine ecosystems. Seaweed products can contribute to all of these goals, though not without tradeoffs. To increase seaweed products' ability to provide climate benefits and other environmental benefits, production needs to be scaled up. Expansion of seaweed farming operations to include offshore waters could help address this need and avoid spatial constraints present in heavily used nearshore waters. We mapped where seaweed could be farmed throughout the world's Exclusive Economic Zones (nearshore and offshore) to support decision-making and investment related to expanding seaweed farming. We used spatial analysis to identify confluences of high productivity, low costs, and ecological co-benefits. We combined models of seaweed production and cost with historical data on ocean acidification, eutrophication, dissolved oxygen, future water temperatures, shipping activity, and fishing intensity. We scaled all variables from 0 to 100 (100 being most favorable) and combined them to create a composite favorability score for seaweed farming. To assign variable weights, we used four scenarios, which prioritized production, environmental stressor amelioration (co-benefits), avoidance of spatial conflicts, or future climate suitability for seaweed farming. A fifth scenario weighted the four priorities equally. We identified locations that scored in the top 20th percentile across all five scenarios and explored geographic differences between scenarios. The resulting maps will assist in identification of opportunity areas for seaweed farming to benefit the climate and the marine environment.

Seasonal variation in seaweed diseases prevalence, growth and carrageenan properties of two farmed seaweed, *Kappaphycus alvarezii* and *Eucheuma denticulatum* in Unguja Island, Zanzibar, Tanzania.

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Euchematoid seaweeds namely *Kappaphycus alvarezii* and *Eucheuma denticulatum* are widely cultivated in marine water of Tanzania especially in Zanzibar Island. But recently due to climate change which resulted into change in environmental parameters especially increase in seawater temperature and salinity, diseases prevalence in seaweed has increased which lead to decline in seaweed production in the country. Therefore this study intended to assess the seasonal variation seaweed diseases prevalence, growth and carrageenan properties of two farmed seaweed, *Kappaphycus alvarezii* and *Eucheuma denticulatum* in Unguja Island, Zanzibar, Tanzania.

Present study show that the prevalence (%) of seaweed diseases was significant higher low during cold season than in hot season, *Kappaphycus alvarezii* diseases prevalence mean value were 34.0±2.14 and 44.0±2.1, t(14)=-5.80, P<0.05 while in *Eucheuma denticulatum* diseases prevalence mean value were 19.33±8.0 and 29.3±2.1, t(14) =-3.50, P<0.05 respectively. However, seaweed growth rate (% increase in fresh weight day-1) was significant higher in cold season than in hot season. *Kappaphycus* mean growth rate values were 3.29±0.06 and 1.57±0.41, F (1) =16.42, P<0.05 while *Eucheuma* mean values were 3.05±0.35 and 2.77±0.44, F (1) =24.28, P<0.05. (P<0.05) respectively. Carrageenan yield (%) and gel strength (g cm2) of seaweed *Kappaphycus* were significant higher in cold season which had a mean value of 52.33±0.961% and 310.38±15.82 than in hot season which had a mean value of 33.36±1.37% and 218±5.31, P<0.05. Similarly in *Eucheuma* whereby in cold season carrageenan yield and gel strength were significant higher with a mean value of 43.82±0.29% and 209±3.41 than in hot season which had a mean value of 36.07±0.79% and 178.92±2.42, P<0.05 respectively.

It is therefore concluded that in order to obtain maximum sustainable yield from seaweed farming, farmers should concentrate on farming during cold season and shift to other activities during hot season. Alternatively, farmers should use biosecurity practices as it has evidently proven to be among of the best mitigate measure in seaweed diseases prevalence. Moreover, the study provides significantly information which contributes to the scientific efforts aiming at sustaining the seaweed industry in Tanzania.

Enzymatic extraction of phenolics and polysaccharides from brown seaweed and antioxidant activity of the extracts

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Seaweeds have attracted great attention for industrial applications as they contain various valuable bioactive compounds. Particularly, brown seaweeds are a rich source of phenolics and polysaccharides (e.g., alginate and fucoidan) with unique properties and biological activities. This study aimed to develop a novel enzymatic method for simultaneously extracting phenolics and polysaccharides from brown seaweed and evaluate antioxidant activity of the extracts. The ability of several enzymes (cellulase and protease in individual and combination) to extract phenolics and polysaccharides was examined. Among the tested enzymes, cellulase demonstrated the highest extraction efficiency. The cellulase-assisted extraction was then optimized using response surface methodology to maximize the content of phenolic and polysaccharides. Under the optimal extraction conditions, the highest phenolic and polysaccharide contents were obtained. The polysaccharides were further fractionated to obtain alginate and fucoidan. The phenolic, alginate, and fucoidan fractions showed potential antioxidant activities. This study suggested that cellulase-assisted extraction is a green and efficient method for simultaneous extraction of phenolic and polysaccharides from brown seaweed and the phenolic, alginate, and fucoidan fractions are a promising antioxidant agent for future applications.

Poster Abstracts in Program

In Silico Approaches of Phytoconstituents from *Caulerpa racemosa* Microcapsules by Heat Effect

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The aims of the research was to investigated the main bioactive component of *Caulerpa racemosa* microcapsules origin from North Sea Central Java Indonesia. The sample was subjected to high temperature (120 °C, 140 °C and 160 °C) for 5 hours through a bioinformatics approach. The present paper provides some useful bioinformatics database in silico approaches (Absorption, Distribution, Metabolism, Excretion, and Toxicity (ADMET) profiles. *C. racemosa* microcapsules were determined using Gas Chromatography-Mass Spectroscopy (GC-MS) as PASS database (Prediction of Activity Spectra for Substances) that it estimates of biological activity profiles for compounds. The results of GC-MS analysis indicated there was one volatile compounds that present on microcapsules were treatment to temperature 120 °C which is propane 2,2-diethoxy and there was three identified on compounds of microcapsules were treatment to temperature 140 °C which was furfural, 2-furancarboxaldehyde 5-methyl- and 3-fluoro-2,5-dimethyl-2,4-hexadien however no one appeared on160 °C. GC-MS analysis revealed microcapsule *C. racemosa* were treated to high temperature were detected compounds in the group alcohols, aldehydes, furans, and esters. The formation of most identified volatile compounds increased during heating, especially from 120 °C to 140 °C is compounds group of aldehydes and furans. PASS database revealed a potential *C. racemosa* microcapsules of the safety next-generation drugs that follow ADMET properties which is predicted to have anti-inflammatory properties

Characteristics of Spray-Dried Powder with Various Wall Materials from *Pyropia yezoensis* Subcritical Water Hydrolysates

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In this study, various wall materials (WMs) were used for spray-drying encapsulation (SPE) of the free amino acids of laver, *Pyropia yezoensis*, hydrolysates obtained using subcritical water hydrolysis. Gelatin, whey protein, starch (potato), and dextrin were used as WMs. Following the spray-drying process, the particles were characterised for color, morphology, moisture content, water activity, size, hydrolysate-WM interactions, and infrared absorption properties using scanning electron microscopy and/or Fourier transform infrared spectroscopy. Additionally, analyses of thermal gravimetrics and free amino acid content were performed. The taurine and GABA content were at their highest levels in powder with dextrin as a WM (323.18 ± 0.38 mg/100 g and 21.70 ± 0.14 mg/100 g, respectively). The SPE efficiency ranged from 25.85% with gelatin to 84.60% with dextrin. These results suggest that the SPE of *P. yezoensis* hydrolysates should be selected with consideration for the purpose and direction of the final product.

Poster Abstracts in Program

Cooking and processing of seaweed to improve consumer acceptance, protein digestion and nutrient bioavailability

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New knowledge about human digestion, nutritional availability, flavour and health benefits of seaweed as a whole food is generated through this collaborative project. Several protein-rich seaweed species in their raw form, including *Undaria pinnatifida* and *Ulva sp*., from New Zealand and/or Singapore are characterised from nutritional and food safety perspectives, and environmental factors affecting seaweed composition are investigated. Seaweed will then be prepared into delicious food products using innovative cooking methods for comparison with extensively processed seaweed to identify benefits of the whole food concept: Raw, cooked, and extensively processed seaweed will be digested in a state-of-the art *in vitro* digestion system representing the stomach, small and large intestines. The latter will contain extracted NZ or Singaporean human gut microbiota to account for differences in diet, and thus in gut microbiota and ability to digest seaweed, between these two populations. Processes through different stages of digestion will be tracked using advanced proteomic, peptidomic and metabolomic techniques and microbiota composition. Metagenomic and metabolomic tools will monitor the longitudinal trajectory of both NZ and Singaporean microbiota and metabolite products during digestion. Results will be integrated to obtain mechanistic insight into seaweed cooking techniques, digestion and nutritional benefits to the consumer, both directly and through the impact of the microbiota, and will inform a human clinical trial.

This presentation includes an overview of the project, results to date and planned next steps. The knowledge generated in this project will inform product development of the next generation of seaweed-based protein-rich foods.

Elucidation of food functionality of farmed *Sargassum horneri* for the purpose of global warming countermeasures

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In this study, we focused on "blue carbon", which seaweed absorbs carbon dioxide, as a measure against global warming, and considered the use of *Sargassum horneri* (or "Akamoku" in Japanese) in food by cultivating akamoku. It was confirmed that the cultivated Akamoku is rich in functionality and is expected to be used in functional foods.

As a result of measuring the general components of cultured *Sargassum horneri* and analyzing the components, it was confirmed that cultured *Sargassum horneri* has more protein, carbohydrates, ash, and dietary fiber than wakame seaweed. The minerals of cultured Akamoku were higher in potassium, calcium, magnesium, iron, zinc, and copper than in wakame seaweed, and in particular, iron was 2.5 times higher, zinc was 3.3 times higher, and copper was 3 times higher. The amount of polyphenols in cultured Akamoku was about 2.6 times higher than that in wakame seaweed, and it was expected to have functionality such as antioxidant activity.

The cultivated Akamoku was a seaweed with abundant dietary fiber, abundant minerals, and a large amount of polyphenols, and was rich in food functionality. It was confirmed that foods with functionality considering human health can be produced while considering measures against global warming.

Poster Abstracts in Program

Molecular docking study of *Halymenia durvillei* extract against VP26 Protein of White Spot Syndrome Virus

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Virus infections have hampered the development of shrimp aquaculture, putting a significant financial strain on the business. White spot disease (WSD) has caused significant mortality in farmed shrimp in many regions. The envelope proteins VP26 are essential in the infection process and interactions with host cells. In this recent study, the bioactive compounds from Halymenia durvillei algae have been investigated by molecular docking against VP28 protein from White Spot Syndrome Virus in Shrimp. The 37 natural compounds of Halymenia durvillei algae identified by GC/MS analysis have shown that *E, E, Z-1,3,12-Nonadecatriene-5,14-diol* have the highest fitness score in the GOLD calculation in molecular docking with 21.9. The docking analysis would be used to identify a drug-like molecule as an immunostimulant, which would then be optimized for a potential treatment for shrimp aquaculture. This is thought to be the role of the inhibitor, which prevents the viral protein from attaching to the receptor and therefore prevents the WSSV infection

Red seaweed derived bioactive ingredients improve animal health and productivity in shrimp, poultry and livestock

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Intensive cultivation of animals reared for human consumption makes them susceptible to stresses arising from overcrowding, heat, ammonia accumulation and diseases. We have specifically identified and extracted novel biologically active compounds known as sulfated Galacto-oligosaccharides (sGOS) from red seaweeds. We administered them to commercially cultivated species of shrimp, fish, poultry and livestock to understand their effect on increasing productivity, tolerance to environmental stresses, as well as resistance to diseases in both lab and field conditions. We find that inclusion of sGOS in the diet increases the survival of shrimp by at least 10%, and their resistance to diseases such as Early Mortality Syndrome (EMS), *Vibrio* infection, and White Spot Syndrome (WSSV) by at least 15%. The increased survival arises due to the immune stimulating activity of sGOS wherein it can specifically upregulate genes associated with anti-pathogen defense mechanisms. The increased survival also correlates well with increased yields for the farmer under field conditions. Benefits were observed in commercial broilers where the sGOS improved weight gain and the average daily growth rate, resulting in lower FCR, while concomitantly improving the immunity and antioxidant status of the birds. In cattle, inclusion of the sGOS in their diet increased nutrient absorption and led to an increase in the fat content in the milk. Our results indicate that red seaweed derived sustainable feed additive rich in sGOS stimulates the immune systems of these animals to sustain the stresses of intensive cultivation, while also facilitating increased nutrient absorption for higher productivity.

Poster Abstracts in Program

Planting seeds of clarity: publication and development of the Australian Standard for Aquatic Plant Names

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Given the rapidly emerging commercial trade in aquatic plants, industry representatives have collaborated to develop a list of standard names for current commercial, and potentially commercial, edible aquatic plant species. Recognising the need for such a Standard, in 2020 the Fisheries Research and Development Corporation (a Standards Development Organisation with Standards Australia) established the Aquatic Plant Names Committee to manage the Standard. The first published Australian Standard for Aquatic Plant Names (AS 5301) included 49 Standard Names representing species from six broad groups: brown algae, cyanobacteria, green algae, red algae, aquatic protists and flowering plants. The Standard defines requirements for using the Standard Names and explains the benefits across the scope of public health and safety, social and community impact, environmental impact, competition, and economic impact. Subsequent to the publication of the first Standard, further Standard Names have been included via a rigorous and consultative application and assessment process

Cytokinin-like activities of some Rhodophyta species from tropical and subtropical waters

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The cytokinin-like (CK) activities were analysed in eight species of Rhodophyta: *Chondracanthus teedii*, *Dichotomaria marginata*, *Gelidium floridanum*, *Gracilaria birdiae* (tetrasporophytes and female gametophytes), *Gracilaria cervicornis*, *Gracilaria domingensis* (field and cultured samples), *Gracilaria tenuistipitata*, and *Hypnea pseudomusciformis* (color and morphological variants). Samples were extracted for 24 h at 10°C in 100 ml 80% ethanol, filtered, rinsed with 80% ethanol, and purified using C18 Sep-Pak cartridges. CK activities were determined using the soybean callus bioassay with activity compared with kinetin standards at concentrations from 1 to 50 µg L-1. *C. teedii* had activities equivalent to 5-10 µg L-1, that co-chromatographed with isopentenyladenine (iP), and riboside-5'-monophosphate (MP), while *Gelidium floridanum* had activities equivalent to 1-5 µg L-1. *D. marginata* and *G. tenuistipitata* showed low CK-activities. Tetrasporophytes and female gametophytes of *G. birdiae* had activities which co-chromatographed with zeatin (Z) with female gametophytes having an extra peak that co-chromatographed with MP. The highest activity (equivalent to 50 µg L-1) was observed in *G. cervicornis*, while *G. domingensis* grown in culture had no activity, but field samples had activity which co-chromatographed with the MP and O-glucosides (OG). The *Hypnea* green strain showed more activity (equivalent to 5 µg L-1) than the brown strain (equivalent to 1 µg L-1) with most activity co-chromatographing with Z. Morphological variants of *Hypnea* had similar activities, but "nigrescens" variant had peaks that co-chromatographed with zeatin riboside (ZR) and isopentenyladenosine (iPR). The results indicate that some red algae studied have potential as biostimulant in agriculture. Financial supports: CNPq, FAPESP.

Effect of intake of mekabu (Undaria pinnatifida sporophylls) on blood pressure lowering and swelling improvement

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This study aimed to evaluate the effects of mekabu (sporophyll of Undaria pinnatifida) ingestion in lowering blood pressure and improving swelling. A randomized, single-blind, parallel comparison study was conducted on 60 individuals with high blood pressure (systolic blood pressure [SBP] > 160 mmHg and diastolic blood pressure [DBP] > 100 mmHg). The participants were divided into two groups, a test food group and a control group. The test food group ingested 35 g of raw mekabu once per day in the morning, noon, or evening, prior to meal intake, for a total of four weeks. SDB, DBP, and pulse rate were measured using an automatic blood pressure monitor, and subjective symptoms of swelling were evaluated by a questionnaire. Salt intake was determined by calculating the 24-hour urinary sodium excretion. No significant changes were observed in SBP, DBP, pulse rate, or salt intake before and after the experiment in both groups. In subgroup analysis, a significant reduction in SBP ($p < 0.05$) was observed in the test food group in those with a pre-experimental SBP of < 140 mmHg. Subjective symptoms of swelling improved in those with mekabu intake. Regular pre-meal intake of mekabu is an effective means of improving swelling, and lowering blood pressure in participants with SBP < 140 mmHg. Part of this study was carried out with the support of the "Reiwa 3rd year public subsidy for creation of new business by small and medium-sized enterprises (Miyagi prefecture)".

Genome-scale protein interactome mapping to predict seaweed anti-cancer secreted peptides

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Seaweeds are multicellular marine macroalgae with natural compounds that have potential anti-cancer activity. To date, the identification of those compounds has relied on purification and assay, and still few have been documented. This study aimed to integrate new seaweed genomic resources with established cancer bioinformatics pipelines to help identify potential seaweed proteins that could help mitigate the development of cancer. To achieve this, we used 12 publicly available edible seaweed genomes (8 species, 268,071 proteins), for putative interactome analysis with human proteins derived from tumor suppressor genes, oncogenes and those with dual roles. We present 7892 protein domains that were predicted to associate with cancer proteins based on protein domain-domain interaction. In total, we identified 3,881,014 interactions, among which 269,172 interactions were initiated by dual-role cancer proteins. The most enriched protein family consisted of those associated with protein phosphorylation and insulin signaling, both of which are recognized to be crucial molecular components for patient survival in various cancers. In addition, we found 6692 seaweed proteins that could interact with over 100 tumor suppressor proteins, of which 147 are predicted to be secreted proteins. In conclusion, our bioinformatic prediction may not only be helpful in evaluating potential anti-cancer seaweed proteins but may also provide a new avenue to explore the molecular mechanisms for seaweed-associated inhibition of human cancer development.

Sodium alginate film properties exhibited when the plasticiser is manipulated

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There is an increasing need to find an alternative resource to make plastic films for the food packaging industry, that is more sustainable than crude oil. Sodium alginate (SA) has film forming capabilities which could provide a biodegradable solution to this problem. However, a plasticiser must be included to ensure adequate water resistance properties for the length of a ready to eat product's shelf life. With plasticiser inclusion into SA films being a relatively unexplored field, this has presented an opportunity to characterize the properties exhibited when different plasticisers are included in a SA film. After the creation of a cast moulding method coupled with oven drying for film formation, films with different physical properties could be created when a plasticiser and its concentration was varied. Various plasticisers were trailed at differing concentrations including carbohydrates, polyols, oils, and cellulose nanocrystals and nanofibers. Each plasticiser produced its own properties once the films had dried. The study defined what plasticiser, and concentrations of more suitable plasticisers, produce physical properties similar to that of plastic films currently used in the food packaging industry. Following this, the exhibited properties of films were characterised when the most suitable plasticisers were incorporated into a film in combination with each other. The plasticiser resultantly produced films with more flexible properties when polyols were included. A higher tensile strength was produced by films containing cellulose. Carbohydrates seem to produce a clearer film, ideal for product viewing. Plasticiser concentration is important in defining how much a property is exhibited.

Characterization of bioplastics developed from *Kappaphycus alvarezii* crosslinked with commercial alginate

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Plastic pollution has become one of the most concerning problems globally due to excessive use of one-time use plastics. However, bioplastics could be the answer to help combat this problem as they are readily biodegradable. Development of bioplastics was done by mixing seaweed biomass into distilled water at specific ratio, using glycerol as plasticizer followed by addition of calcium chloride to enhance the binding of bioplastics developed. Bioplastics were developed at the ratio of 100:0, 75:25, 50:50, 25:75, and 0:100 *K. alvarezii* to commercial alginate ratio. Characterization was done based on their appearance, mechanical properties, thermal properties, permeability properties, biodegradability, and shelf life. Resulted data for their appearance showed that when more *K. alvarezii* was in the mixture there were more colour difference in comparison to white background and the same trend for the opacity due to the natural colour of whole *K. alvarezii*. As for their mechanical properties, tensile strength of the bioplastics decreased from 100:0 ratio to 0:100 ratio at 7.91±0.45MPa (100:0), 6.78±0.31MPa (75:25), 5.20±0.37MPa (50:50), 4.13±0.17MPa (25:75) and 3.76±0.14MPa (0:100), respectively. Same goes for their elastic modulus at 20.93 ± 0.61MPa (100:0), 16.47±0.99MPa (75:25), 11.42±0.53MPa (50:50), 8.78±0.45MPa (25:75) and 6.65±0.32MPa (0:100), respectively. This shows that the addition of alginate enhances the elasticity but decreases tensile strength. As a conclusion, developed seaweed-based bioplastics resulted different properties at different mixture ratio show potential to be incorporated into the market as they are a greener option to fight single-use plastic wrappings such as beverages and food additive packets.

Optimization of biomass to water ratio and glycerol content of bioplastics developed from *Kappaphycus alvarezii*

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Macroalgae are actively being used in various industries. However, there is high potential for them to be applied as base material for bioplastics, either as a whole or their extracts. Previous studies of bioplastics development using seaweed base material show potential of being incorporated into various industries, at the same time help reduce single-use plastics. Development of bioplastics was done by mixing biomass into distilled water at respective ratio (1:50 - 1:90 (w/v)), heated to 60oC. Then, using glycerol (1 – 5 % (v/v)) as plasticizer was added which was later heated to 80oC. By using casting method, solution was poured into petri dish then dried at 50oC overnight. Bioplastics' properties, such as, appearance, functional groups, mechanical properties, thermal properties, permeability properties, biodegradability, and shelf life, were characterized. Resulted data showed that tensile strength decreases while elongation-at-break, water vapour permeability increases from 1:50 to 1:90. The same trend from 1% to 5% (v/v) glycerol added. As for their appearance, as the biomass were dissolved in more water, their colour intensity and opacity decreases. Same goes for when more glycerol was added because their intermolecular bond loosens resulting in lower colour intensity and opacity. All samples developed were highly biodegradable and their shelf life all lasted more than 14 weeks. As a conclusion, to replace single use plastic optimum mixture was at 1:60 biomass to water ratio with 1% glycerol content. However, developed seaweed-based bioplastics resulted different properties at different mixture ratio which can be applied specifically according to their purpose.

Analysis of bromoform in *Asparagopsis* seaweed and downstream-processed feed additives; first NATA-accredited method in Australia

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Bromoform has been shown to significantly reduce methane outputs from ruminants, even at low-percent inclusions in feed. The red macroalgae *Asparagopsis* spp is a rich source of naturally occurring bromoform, and commercial production is increasing in Australia. Levels of bromoform present in each processing and extraction step can differ due to a range of variables in processing and raw materials used. Additionally, the volatile nature of bromoform means levels can be markedly affected by processing and storage conditions. It is therefore crucial to employ a robust method for analysing bromoform in a wide variety of matrices. Here, we present the first NATA-accredited method (National Association of Testing Authorities, under ISO/IEC17025) for analysis of bromoform in seaweed and oil-based extracts. Expansion of the method to other matrices, including feed pellets, animal tissue, and milk has also proven successful.

Poster Abstracts in Program

Uptake of ammonium nitrogen in fish aquaculture wastewater by Japanese algal family Gracilariaceae

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Nutrient loading from fish aquacultures is one of the major aquatic environmental degradation, although fish aquaculture is important for food sources. High concentrations of nutrients often promote phytoplankton blooms. Harmful phytoplankton releases large amounts of shellfish toxins. Any effective solutions to the environmental problem are now requested. On the other hand, marine macro alga uptakes a large amount of dissolved nutrients such as nitrogen and phosphorous during algal growth. Thus, macro alga is one of the candidates that can be used to reduce dissolved nitrogen and phosphorus in fish wastewater. The aim of this study was to evaluate the uptake of ammonium nitrogen in fish wastewater by Japanese algal family Gracilariaceae. The time course of nutrient loading from fish into seawater after feeding was investigated under various conditions. Fifteen kinds of unialgal culture strains of the Japanese algal family Gracilariaceae were surveyed for ammonium nitrogen uptake. Ammonium nitrogen concentration in seawater was determined by using a continuous flow analyser Model QuAAtro. Among Japanese Gracilariaceae tested, *Gracilariopsis chorda* strains had a large intake of ammonium nitrogen. A *G. chorda* biofilter with algal density of 1 g / L reduces ammonium nitrogen below the Japan standard value (dissolved nitrogen 1.00 mg / L) in 24 hours. *Gracilariopsis chorda* is one of the industrially important macro algae in Japan, it can be used for foods and food additives such as agar after nutrient uptake. Thus, *Gracilaria chorda* seem to be suitable alga as a biofilter.

From marine invader to shrimp aquaculture life saver: *Asparagopsis armata* extracts against *Vibrio parahaemolyticus*

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The increase of human population has created the need for intensive food production, being aquaculture one of the solutions used to supply seafood. In Asia, the shrimp farming industry has increased in the last 4 decades. However, the intensive aquaculture is a risk factor for disease outbreaks and consequent mortality of the living stock, leading to elevated economic losses. The Acute Hepatopancreatic Necrosis Disease (AHPND), caused by *Vibrio parahaemolyticus*, was firstly registered in China in 2009 and spread to Vietnam, Malaysia and Thailand, and is characterized by the hepatopancreas destruction of the animal, causing high percentages of death and major economic losses.

Asparagopsis armata is an invasive seaweed in Portugal with a recognized biotechnological potential for the feed industry. An ethanolic extract from this species already demonstrated activity inhibiting *V. parahaemolyticus* growth in vitro and reducing AHPND-related death in vivo when a supplemented diet is used to feed the whiteleg shrimp *Litopanaeus vannamei*. The main goal of this work was to decipher the mechanism of action of this extract regarding its anti-Vibrio activity, through biochemical and molecular analyses, in order to understand effective mechanisms against this disease.

The results showed that at minimal inhibitory concentration (2 $mg.mL^{-1}$) the mitochondria activity and the biofilm formation decreased with increasing concentrations of extract and time intervals, while extracellular protein content increased in the same conditions. Regarding the real time quantification of genes potentially involved in these mechanisms of action, a global tendency was found, with an increase of gene expression with increasing concentrations of *A. armata* extract, and is further depicted in this work.

Poster Abstracts in Program

Effects of food extruded with macroalgae meal on the development of juvenile sea urchin Loxechinus albus in southern Chile

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In Chile, diets based on macroalgae to feed sea urchins started in the 1990s. Here, the researches were focused on the effect of growth and gonadal quality of adult individuals. In this study, we evaluated the effect of extruded foods, where the macroalgae Macrocystis pyrifera, Sarcothalia crispata, Ulva spp. and Pyropia spp. were incorporated, for improving growth and survival rates of juvenile of L. albus destined for restocking. Bioassays were realized at the same time in Los Lagos and Magellan regions between the fall and winter of 2021, with a duration of 90 days. In Magellan region, the temperature was colder than Los Lagos region, the first ranged between 3 and 6°C, and the second between 10 and 12°C. A total of 375 juvenile sea urchins (from 5 to 15 mm) were used to record food consumption, growth rates and survival. Four diets containing macroalgae meal and various protein concentrations and energy levels were used, plus a control diet with live macroalgae. Significant differences were observed in the average percentage of food consumption in the different diets ($p<0.01$). Growth rates also showed significant differences according to the diet ($p<0.001$). Food consumption was higher in Los Lagos region, probably associated with higher temperatures. Conversely, in Magellan region, growth rates higher than in the control treatment were recorded. Survival ranged between 70 and 85%. Results are consistent with the viability of using inert diets for the development of juvenile L. albus. This lays the foundation for future sustainable development of the resource.

Improvement of fermentable monosaccharides production from *Ulva lactuca* biomass as response to abiotic factors modulation

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Seaweeds are important autotrophic organisms that produce numerous metabolites with potential for biotechnological application, such as carbohydrates, which can be used to generate bioethanol. Thus, with the aim of maximize the production of fermentable monosaccharides from *Ulva* biomass, this study evaluated the combined influence of light, temperature and availability of nitrate and phosphate, using the factorial design technique, on the growth, photosynthesis, and monosaccharides content of *Ulva lactuca* from Ubatuba, SP, Brazil. The content of total lipids and fatty acids was also accessed since they can be used as nutraceuticals and aggregate value to the use of the biomass of macroalgae. The seaweeds were cultivated by ten days, with the abiotic factors varying as following: irradiance - 50 to 150 mmol photons m2 s^{-1}; temperature - 15 to 30 °C; nitrate concentration - 20 to 250 mmol L^{-1}; and phosphate concentration: 2 to 18 mmol L^{-1}. The highest growth rate and photosynthesis, obtained at high irradiance and high nutrients availability, were 17% d^{-1} and 70.1 mmol electrons m2 s^{-1}, respectively. The omega-3 concentration was also higher under these conditions, reaching 50% of the total fatty acid content. The highest concentration of total monosaccharides and glucose were 128 and 73 mg/g dry mass, respectively, and occurred in the treatment with the lowest concentration of nitrate. The results show the importance of cultivation conditions for maximizing the production of the compound of interest as well as the potential of *Ulva lactuca* to produce bioethanol and other compounds.

Poster Abstracts in Program

The overlooked potential of tropical seaweeds in the Pacific – an assessment of opportunities in New Caledonia.

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The seaweed industry is booming, opening new opportunities for many countries outside traditional producers in Asia to participate in the global market. In the South Pacific, Australia is setting an example. Over the past four years, the country has developed significant expertise, raised substantial funds and launched a national alliance to stimulate the industry in various sectors including human, animal and plant nutrition or environmental remediation. Elsewhere in the region, seaweed production is mostly limited to introduced *Kappaphycus* and *Euchema* spp. for the carrageenan market, with only a few other species traditionally harvested for food (e.g., *Caulerpa* in Fiji). However, new projects are emerging, such as cultivating sea grapes (*Caulerpa*) in Niue or Mozuku (*Cladosiphon*) in Tonga, and notably in French Polynesia where efforts have been developed to unlock the untapped potential of their local seaweeds for food, cosmetics and pharmaceuticals. However, in most other tropical Pacific countries, there is still a lack of knowledge about the potential of native species. This is the case in New Caledonia where the diversity and ecology of local seaweeds are well documented, but their potential as an economic resource has been virtually unexplored. This untapped diversity offers many opportunities for value-added products that can stimulate local blue economies by producing local nutritious and sustainable blue foods, agro and aqua-feed, fertilizers, biomaterials or nature-based environmental solutions. Here we assess the potential of New Caledonian species as a new indigenous resource and select species with the highest potential for relevant local and regional applications.

Potash derived from rhodophytes (SAGAR Amrit) and its derivatives on the tuber yield and starch content of cassaca root Manihot esculenta Crntz

Dr Munisamy Shanmugam

Aquagri Processing (p) Ltd

Agricultural bio-stimulant obtained from fresh biomass of seaweed Kappaphycus alvarezii was separated into organic and elemental rich fractions using nano filtration system. Both the fractions were spray dried separately in order to get organic and elemental rich product and Ntechniques and they were spray dried into powders and applied on the cassava root at 500 g ha-1. The elemental rich fraction had 84.55% of KCl in it. Spray dried mother biostimulant and chemical KCl were also tested in parallel for comparison studies. The tuber yield and starch content of cassava applied with elemental rich product was similar to its mother sample and chemical KCl and result of organic rich were similar to control cassava. Three products were tested on cassava root i.e. (1) the mother product Biostimulant and its fractions (2) Organic rich fraction and (3) Elemental rich fraction which has 85% of Muriate of potash on tuber yield and starch content. Muriate of potash has about 85% KCl, and total organic rich product from mother bio-stimulant was 12%. The elemental rich fraction (E-Fraction) had 85% KCl + 8% NaCl and remaining with other elements whereas the organic rich fraction (O-fraction) had 65% organic matter and 23% KCl 6% NaCl. The bio-stimulant of *K. alvarezii* was tested to contain 85% of elements, 12% organic matter with 3% moisture and it has influenced the yield of cassava to 21.45% with high content of starch as compared to control plants.

Poster Abstracts in Program

Selection of marine algae for nutrient biofilter and bioproduct trials in the GBR coastal region

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The capacity of many seaweed species to rapidly absorb soluble nutrients and convert them into primary biomass provides opportunities for their use in the bioremediation of nutrient enriched waters (Gorgula & Connell 2004; Worm & Lotze 2006). Marine-based aquaculture of seaweed has the potential to target diffuse source nutrient discharges, capture carbon and produce valuable bio-products such as fertiliser, soil conditioning agents and agricultural fodder (Roque et al 2019; Mansori et al 2015). Australia boasts an enormous diversity of seaweeds, with over 3,000 species currently recorded, many of which are endemic (Womersley 1987). Such diversity presents benefits for maintaining healthy marine ecosystems, but also a challenge for determining the potential to use native seaweed as a nutrient biofilter, and ultimately, a source of bioproduct. Ideally, species used for biofiltration should grow rapidly to a size where adequate biomass can be obtained, while also being amenable to laboratory-based culturing for subsequent out-planting in identified field locations (i.e. seaweed mariculture). We applied a multi-criteria selection model developed for the purposes of identifying likely candidate seaweed species for biofiltration and bioproduct development; in particular, for fertilizer and agricultural/horticultural use in Queensland's coastal waters. Species were selected based on their abundance and distribution, habitat-euryhalinity, form and life history traits. From a species database of 1,380 algal species, our selection model resulted in a shortlist of 21 macroalgal species as promising biofilter candidates to improve water quality along the Great Barrier Reef Marine Park (GBRMP) coastline.

Poster Abstracts in Program

An *in vitro* evaluation of seaweeds as future feeds for cattle

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Rumen degradability (RD) of organic matter (OM) and contents of nitrogen (N) and ash are important for the nutritional value of being feeds for ruminants. Contents of N and ash vary considerably among seaweed species, with RD more sparsely documented. This study aimed to investigate N and ash contents and *in vitro* RD of 22 seaweed species procured from the Northern hemisphere, including both red, green, and brown seaweeds. Effects of harvest time were investigated in four of the species. Total N content was measured following the Dumas principle. Rumen degradability of seaweeds was analyzed by incubating 0.5 ± 0.02 g of seaweed with rumen inoculum, using the Ankom RF system. After 48 h of incubation, degradability of dry matter (DM) and OM were determined. In general, red species had the highest contents of N, ranging from 2.6-5.7% of DM, followed by brown and green species, ranging from 1.0-4.1% and 1.0-1.7%, respectively. Green species had the highest ash contents, 45.4 ± 9.2% of DM (mean ± SD), while brown species had the lowest contents, 31.9 ± 9.7%. Across species, brown species had significantly lower contents of degradable OM per g DM compared to red and green species. Harvest time did not affect N and ash contents or degradable OM per g DM across seasons. In conclusion, large variations in RD, and contents of N and ash were found between the species; however, some Nordic species show potential as future feeds for cattle.

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Ancestral and current uses of the *Pyropia/Porphra* (luche) red algae complex in southern Chile and recommendations for its sustainability

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The *Pyropia-Porphyra* complex in southern Chile has been consumed since ancient times by coastal communities and indigenous peoples. It is harvested manually during low tide, mainly by women. Its preparation, maintenance and commercialization are artisanal. The objective of this work was to obtain information on collectors, extraction sites, processed products and sustainability of the fishery in southern Chile. Official landing statistics (SERNAPESCA) were also analyzed. The results indicate that between 2012 and 2021, there is a sustained increase of exploitation in natural beds, from 12 t to 200 t per year. There are 1,690 active seaweed collectors in the southern zone, 73% of whom are women. The algae harvested from natural beds show morphological variability and generally the fishermen harvest in very distant places during winter, spring and summer season, the latter being the most important in terms of volume. The average age of seaweed collectors is around 54 years and in general they have a low educational level. The yield per collector is variable and they work between 1 to 3 hours per day, with favorable tides level. Marketing is individual and they sell the seaweed dried compacted, smoked compacted, and sometimes freshly harvested. Recently, an emerging market has been developed by entrepreneurs who provide dehydrated ground or flaked products in offer dehydrated products in ground or flaked form in hermetically sealed, labeled packages. Natural caption of spores in natural beds is presented as a sustainability mechanism for this fishery.

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Red algae (Rhodophyta) *Sarcopeltis skottsbergii* meadows in the southern Chile: current status and strategies for sustainability

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Sarcopeltis (ex *Gigartina*) *skottsbergii* is one of the most representative species of carragenophyte red algae in the algal fisheries of southern Chile. According to fishery statistics, during 2010-2016, the average annual landing of *S. skottsbergii* was 25,436 wet tons. Of this, 98% of the biomass landed came from natural beds of southern Chile. The aim of this study was to evaluate according to biological, fishing and socio-economic antecedents the main natural beds of *S. skottsbergii* in the southern region: Los Lagos, Aysén and Magellan regions. Biological results showed the highest values in biomass, density, and species richness in the Los Lagos Region. The recruitment was seasonal and occured mainly in the summer period. Reproductive phenology showed latitudinal gradients, with different proportions of phases and number of reproductive structures. The results showed that the harvesting period occurs between Oct-Mar in Los Lagos and Aysén regions, while in Magellan region between Sep-May. The main landing sites during the 2010-2018 period were Quellón, representing 91% of Los Lagos region, Melinka with 91% of Aysén region, and Punta Arenas (42%) and Puerto Natales (41%) in Magellan region. The socio-economic fishing results showed inconsistencies between the number of people authorized for shore collection and the declared activity (only 1% declared). During workshops with public and private institutions of the fishing sector, strategies for sustainability, and administrative measures for fishery of the species were proposed.

Enhanced enzymatic-hydrolysis of *Cladophora glomerata* by freeze-drying of cellulase from *Trichoderma viridae* for bioethanol production

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The effect of freeze-drying cellulase from *Trichoderma viridae* on acceleration of *Cladophora glomerata* hydrolysis for saccharification in bioethanol production was provided. *C. glomerata* gave cellulose, hemicellulose, lignin, and ash content [Mean (%) ± SD; n=3], with 35.28 ± 3.36, 20.00 ± 1.20, 3.45 ± 1.57 and 15.07 ± 9.09, respectively. Among 4 crude cellulase preparation methods as ethanol 95%, acetone, ethanol 95% + acetone, and ammonium sulphate, it was found that acetone precipitation was selected with the highest enzyme activity [Mean (FPU/g solid substrate) ± SD; n=3] as 139.05 ± 10.35 from total enzymatic protein amount [Mean (mg/g solid substrate) ± SD; n=3] as 485.23 ± 48.81. After freeze dryer technique was applied to crude enzyme, cellulase activity [Mean (FPU/g solid substrate) ± SD; n=3] /protein [Mean (mg/g solid substrate) ± SD; n=3] was equivalent to crude enzyme without freeze-drying with no significant differences ($p \le 0.05$). Saccharification of algae using freeze-dried cellulase at 4, 25, 35 and 50 °C using 5 mL [enzyme powder 0.021 g (6.59 mg protein content)], 10 mL [enzyme powder 0.0424 g (13.18 mg protein content)] and 15 mL [enzyme powder 0.065 g (19.77 mg protein content)] was determined to obtain the appropriate condition. It showed that at 4 °C, the freeze-drying enzyme 0.065 g (19.77 mg protein content) yielded the highest reducing sugar [Mean (mg/g dry weight algae) ± SD; n= 3] as 119.81 ± 11.33, which had higher efficiency of reducing sugar release than crude enzyme without freeze-drying (control) in all treatments.

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What do we mean by "sustainable seaweed"? Stakeholder perceptions of a 'sustainable' Australian seaweed industry

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The emerging Australian seaweed industry is often described as one of great potential – for creating healthier oceans, regional jobs and reducing Australia's carbon emissions. Momentum within this industry is building rapidly, with seaweed production framed as a 'sustainable' development option for coastal regions. But terminology such as 'sustainable' often remains vague, leaving space for miscommunication and misunderstanding between stakeholder groups, creating the potential for poor project outcomes and issues with community support. Our research systematically reviewed global academic literature that discusses 'sustainable' seaweed production, critically analysing the use of terminology and exploring potential repercussions of having conflicting, contradictory or ill-defined ideas of what 'sustainable' means. Survey data collected from Australian stakeholders further explored the varying ways in which groups understand 'sustainability' in the context of seaweed production. The survey results from 12 stakeholder groups will be presented in the context of understanding the differing expectations groups may have regarding what Australian seaweed production must or must not include if they are to describe themselves as 'sustainable', and how these expectations can affect the social license of future seaweed production ventures.

Production of *G. changii* microplantlets using *Ascophyllum* Marine Plant Extract Powder (AMPEP) as phycobiostimulant

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Gracilaria is a red seaweed known to be a good source of agar and agarose. This is a cosmopolitan seaweed both found abundantly in the temperate and tropical waters. *Gracilaria* is ubiquitous in the Philippines, however, no report yet on the micropropagation using tissue culture technique of this seaweed has been made.

A study on the use of seaweed extract phycobiostimulant (PBS) in the form of *Ascophyllum* Marine Plant Extract Powder (AMPEP) was conducted to assess the efficacy of this seaweed extract as an elicitor of shoot formation and as a stimulator of growth rate to generate new seedlings for future field cultivations. Results show that a 0.5% of AMPEP is significantly higher in shoots (7.5 mm ± 0.88) than all other concentrations (1,3, 5 %) but not with Control at $p < 0.01$. In terms of the number of shoots per section, a 1.0 mL/L and 5.0ml/L AMPEP were significantly higher at $p < 0.01$ than control whereas 0.5 mL/L and 3.0 mL/L are inconclusive. The survival of section with shoots in all concentrations after 45 days of in vitro culture was 100%. These findings demonstrate the efficacy of a seaweed extract PBS in generating a fast, simple and inexpensive technique of generating new plantlets for field cultivation. However, upscaling the production is highly encouraged to promote sufficient good quality seedlings for sea-based nursery and ultimately field cultivations purposes.

Technology Verification on the Land and Sea-based Cultivation of *Sargassum* in the Philippines

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The techniques pioneered by Largo et al., 2020 on the land and sea-based cultivation of *Sargassum aquifolium* were verified using *Sargassum kushimotense* collected in Bulusan, Sorsogon, Philippines. Fertile eggs of this species were collected/recruited through vigorous shaking and spontaneous discharge procedures. The 24-hour microscopy observation of eggs showed that cell divides from 3 to 9 hours. Some zygotes started to develop rhizoids on the 12th hour then became visible in 18-24 hours. At day 7, a total of 117 germlings (<.5mm-5mm) from the eggs collected through vigorous shaking have settled on the artificial clay panel substrates while only 53 germlings (<.5mm-5mm) from the eggs recruited through spontaneous discharge were observed to have attached to the artificial substrates. The number of germlings on the substrates has increased until day 63. And at day 90, the survival rate of germlings in the land-based hatchery was at 99-225% with a daily growth rate that ranged from 2.9 to 4.7%.

Young plantlets (20 mm) were cultivated in the field using the floating longline method. Bladelets were observed to develop rapidly. After 3 months of field cultivation, the survival rate of the plantlets is 100% and the daily growth rate ranged from -0.43 to 1.37%

Sargassum cultivation techniques introduced by Largo et al., have been proven to be viable in the study area. However, further studies are necessary to develop more strategies that will further improve the quantity and quality of produced plantlets.

Integrating Indigenous fishery practices with modern technology in restoration efforts of native fish and seaweed

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Loko i'a (Traditional Hawaiian fishponds) were engineered to attract and maintain fish to sustain communities. The established nursery grounds at Waikalua Aquatic Institute in Kāneʻohe, Oʻahu comprises a flow through system of fish effluent, nutrient rich water that simultaneously provides nutrients for the native algal biomass, while filtering this water before returning to the fishpond. This process mimics the natural filtration that happens in fully functioning loko iʻa. With research being developed in the first nursery grow-out aquaculture system of its kind, baseline procedures are underway which determine best practices for supporting such facility. Research being developed focuses on the overall efficiency of the feed (marketed fish food vs chicken feed) being given to juvenile fish that not only supports the growth of the fish but also passed down nutrients that supports the growth of vegetation, which in this case is limu. Although preliminary results provide insight of feed type having no effect on the growth of fish, research suggests that there is a difference in the quality of nutrients passed down to the vegetation, resulting in diminished growth of vegetation based on specific feed. Success in the integrated restoration efforts to grow out native fish and limu within loko i'a can establish critical nursery protocol that may be utilized by networks of other local fishpond managers, as we restore indigenous sustainable fishery practices.

Comparison of three culture methods of red seaweed in coastal waters off northern Sri Lanka

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Seaweed *Kappaphycus alvarezii*, was recently introduced to Sri Lanka. But suitable culture methods; solutions for fish grazing; and suitable culture sites have not yet been investigated under native conditions. Thus, this study compared the growth of *K. alvarezii* under different culture methods and to find a method to minimise fish grazing as it reduces the harvest and contributes to further spreading. Growth rates of *K. alvarezii* were tested under 3 culture methods, "raft"; "line"; and "cylinder-cage" at two sites in northern Sri Lanka. Each of these methods consisted of three replicates. Around 60 seedlings of a unit weight of 60-100g, were tightened into each raft and line, while inserted into cylinder cages. In 3-day intervals, 5-randomly selected seedlings were weighted & replaced from "line" and "raft", while "cylinder-cage" was weighted as an entire unit, in determining the percentage growth rate & weight lost. Among the 3-culture methods, cylinder-nets resulted in the highest growth rates of *K. alvarezii* & highest economic profits ($p<0.05$). Mechanically damaged seaweed parts were remaining inside the cylinder net resulting in zero weight loss and further spreading. Cylinder nets can frequently be cleaned to avoid clotting due to their smaller size. The growth rate of *K. alvarezii* was redundant after 40 days thus, harvesting is recommended ~40th day of the culture cycle. At this stage, reproductive structures were not reached to its maturity hence spreading due to sexual reproduction was minimum.

A comprehensive study should be conducted in analyzing the associated environmental risks before popularizing *K. alvarezii*.

Seaweeds for a sustainable future – The Blue Food Centre, Sweden

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The future is "Blue" we need to unlock the potential of the oceans for mariculture in-order to achieve a prosperity for humanity. This work presents the new Swedish "Blue Food Centre" where seaweed cultivation and the utilization of the biomass for food and fed are an essential part of the 13 million € investment with eight academic partners and 70 industrial companies from the seafood sector. The human population will increase from 7.3 billion people in 2015 to 9.8 billion by 2050 and reach 11.2 billion by 2100. The oceans can help to satisfy the global demand of food by both direct food production or indirectly by the harvesting of biomass for fed. The current and growing population is both a nutritional challenge connected with hunger, undernutrition and micronutrient deficiencies. But also, a growing global demand for food and biomass. The total food demand is projected to increase by 60 % by 2050. Our oceans are home to a large number of resources that are marginally or not exploited and may improve food security and wellbeing for humans. A sustainable use of this resources could release some of the pressure that has been put on both land-based agriculture and industrial fishing and may also have a positive environmental impact on the global, regional and local environment. Today's exploitation of ocean resources is not sustainable from both social, economic and environmental aspects. The potential is connected with mariculture that may increase 50-100 times if focused on low trophic levels e.g., seaweeds.

Protocol to biomass production of the green seaweed *Ulva ohnoi* from germling clusters

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The aim of this work was to establish protocols for the biomass production of *Ulva ohnoi* using germling clusters. Germling development from zygote germination was evaluated under different densities (10, 20, 30, and 40 x 10^4 gametes mL^{-1}), nutrients (4, 8, and 16 mL L^{-1} of von Stosch standard solution), and irradiance (100, 200, and 300 µmol photons m-2 s^{-1}). The influence of density or nutrients on the growth of the seedling clusters was evaluated by adding weekly or daily nutrients to the culture medium. In all these treatments, growth rate and productivity were calculated. The irradiance of 200 µmol photons m^{-2} s^{-1} was the main factor that affected germlings' development. The zygote density was not high enough to form germling clusters; thus, densities above 40 x 104 gametes mL^{-1} should be investigated. The nutrient concentration did not present significant differences in the germling's development, so the lowest concentration (4 mL L^{-1}) is recommended. Regarding germling clusters, the lowest density (0.1 g L^{-1}) is indicated, as it provided the highest growth rate (59.52 ± 4.39% day^{-1}). Also, 8 mL L^{-1} of von Stosch solution is sufficient for germling clusters growth. The maximum cultivation period under the conditions tested was four days. Density is also a limiting factor from the fourth day onwards; harvest and adjustment to the initial density are indicated.

A model experiment on discoloration and recovery of *Pyropia suborbiculata*

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Discoloration of *Pyropia* refers to deterioration of the quality of laver as well as the production due to the color change and detachness of frond with lack of nutrients in seawater. In this study, we investigated that the critical concentration of nitrogen causing the discoloration of *P. suborbiculata*, the effective period for the recovery of the discolored thalli, and the appropriate nutrient concentration. To calculate critical nutrient concentration that causes the discoloration of the thalli, culture experiment was conducted at 5 DIN concentrations (30, 50, 70, 90, 110 mg L^{-1}) for 14 days. To test recovery of discolored thalli, culture experiment was conducted at 4 NH4-N concentrations (10, 20, 40, 60 mg L^{-1}) for 96 hours. After 8 days culture, discoloration of thalli was induced according to the nutrient concentration between 70 and 90 mg $L^{-1}$of dissolved inorganic nitrogen. When the nutrient deficiency period was less than 10 days, the color recovery of the discoloration-induced thalli was significantly recovered within 48~72 hours when NH4-N was treated with 20 ppm. In this study, we revealed that the discoloration of *Pyropia* caused by the lack of nitrogen concentration in culture farms can be restored by supplying nitrogen within an appropriate period and concentration.

Potentially toxic elements in seaweed and how to extract them

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Healthy. Sustainable. Novel. Seaweed is a front figure for the green transition in the blue revolution. Yet, it is widely recognized that the prevalence of potentially toxic elements (PTEs) in many seaweed species constitutes a threat to their role as a sustainable food resource. From this starting point, we focus on inorganic arsenic (iAs), cadmium (Cd), lead (Pb), and mercury (Hg), as these compounds are considered 'chemicals of public health concern' by WHO. Analysis was performed by accredited labs: element analysis using HR-ICP-MS and arsenic speciation HPLC-ICP-MS. Our study shows that the levels of these compounds vary in four different species (*Saccharina latissima, Alaria esculenta, Palmaria palmata*, and *Ulva lactuca*), between three growth locations (Sweden, Norway, and Ireland), and within the algae itself (top, base, and stipe). Ultimately, six different extraction methods were employed to reduce levels of these PTEs. Up to 92 % iAs, 2 % Cd, and 47 % Pb could be removed by the different methods. Hg was concentrated in all samples after treatment, although present only in small quantities. iAs comprise a minor fraction of total arsenic (tAs) in untreated seaweed, ranging between 0-9 %. The results suggest that some PTEs can easily be removed by scalable industrial extraction methods. Biosorption mechanisms are seemingly different for the various compounds. And of the studied compounds, Cd represents the biggest threat to seaweed food safety. Accordingly, standardized acceptance criteria are required, and further analysis on Cd removal might be of interest.

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Cultivation of Tasmanian *Caulerpa* for food: a potential high-value seaweed product

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Seaweeds have a recognised high value in the niche fresh seafood market in Australia, met primarily by imports. However, Southern Australia, particularly Tasmania, has a high diversity of seaweeds that can meet this domestic demand. This study investigates the viability of growing native Tasmanian *Caulerpa* species in aquaculture with the goal of producing a healthy, sustainable, and desirable human food source. We examined the regrowth potential and palatability of *Caulerpa* species which are morphologically similar to the highly valued *C. lentillifera* and *C. racemosa*.

We identified six vesiculate, native Tasmanian *Caulerpa* species as candidates for aquaculture: *C. geminata, C. cactoides, C. simpliciuscula, C. sedoides, C. hodgkinsoniae*, and *C. vesiculifera*. The regrowth potential of a subset of these species was tested in lab experiments where fragments of various size and morphological type were cultured and the percentage of fragments regrowing and growth rates (increases in length, surface area and biomass) of fragments determined. Generally, these species had high levels of regrowth during the experiment, but this varied with species, fragment size and fragment type.

The palatability of Tasmanian *Caulerpa* species in human taste tests was generally considered to be positive, although there were some key differences among species in areas such as overall enjoyment and texture. Overall, these experiments suggest Tasmanian *Caulerpa* can be grown in land-based aquaculture systems, but that some *Caulerpa* are more desirable than others and should be prioritised for cultivation. The next stages of this project aim to optimise cultivation conditions and upscale production of these species

Learnings from seaweed farming in Ireland and potential of IMTA

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Integrated Multi Trophic Aquaculture (IMTA) systems are based on multiple aquatic species from different trophic levels, farmed in an integrated way to improve efficiency and reduce waste. The utilisation of nutrients through the trophic system are one of the main advantages of IMTA. Further to nutrient sharing, there are the many operational benefits an established industry, such as shellfish aquaculture, could bring to start-up seaweed aquaculture. Traditional Hand harvesting seaweed has been around for centuries in Ireland, however, seaweed farming is still in its infancy. Currently, the seaweed farming techniques used are based on small scale studies and/or academia. Translating this knowledge to a marine site, on a commercial scale, comes with its challenges. Working with operators such as long-established aquaculture farmers (e.g shellfish) in the local area can be of huge benefit. Where academia can support with R&D, working with experienced farmers can bring in practical marine knowledge, logistical solutions and local know-how. They are also likely to have key local connections and strong stakeholder engagement. In Ireland, the grow-out phase of the kelp to harvesting lasts from October to April. From our experience, shellfish farmers's busy periods are in the summer months. Sharing of staff, resources and expertise would create all year-round work and integrate different sectors of the aquaculture industry providing highly skilled and motivated staff. Along with generating social benefits, implementing an IMTA system will bring environmental benefits and improve perceptions of aquaculture in the area.

SølKelp -North-South Seaweed Cultivation Partnership

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While commercial seaweed farming in Europe barely exists compared to the global scale, in recent years a very dynamic industry branch has evolved, with several small-scale cultivation activities, both in the sea and on tanks inland. In Norway, especially brown seaweed (kelp) has been increasingly targeted as raw material, as its pristine cold waters in relatively protected zones are ideal for the initial industry phase of kelp cultivation. However, competition for suitable farm areas is foreseeable. This and the fact that geographic spread will substantially reduce the risk of volume losses in case of diseases or other technical risks, makes it a very interesting scenario to explore the vast ocean areas potentially available for farming in Portugal.

In a similar fashion, production of the highly sought-after red seaweed species *Palmaria palmata* in tanks in Portugal is limited due to high water temperature in summer. By tapping Norwegian waters, production of this species can be approached broader by Southern -European companies, which thus can enhance security of supply for larger productions volumes.

The EEA-financed project SølKelp - North-South Seaweed Cultivation Partnership is an example of geo-strategic collaboration of two undertakings on opposite ends of Europe, making mutually use of cultivation conditions that do not exist in their home region. This contribution summarises the findings of the first season of the project and gives an outlook on how such new challenges and opportunities can add a relevant pillar to commercial operations' portfolios.

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The effect of cultivation conditions on pigment content and net photosynthesis of *Ceramium tenuicorne*

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Ceramium tenuicorne (Ceramiales, Rhodophyta) is widely distributed red macroalgal species in the Baltic Sea. The species has lately earned increased attention as a potential source of highly valued bioactive compounds, first for extraction of the red pigment R-phycoerythrin of analytical grade purity, which is commonly used for its fluorescence properties in biochemistry and as a marker in cell studies. As a part of the development of technology suitable for land-based cultivation of *C. tenuicorne* laboratory experiments to test the effects of light on pigment content and net photosynthetic rate were carried out. The aim of this study was the optimization of cultivation conditions to obtain biomass which quality is suitable for the extraction of the pigment (high content of R-phycoerythrin) and provide high growth rate of the species. The results showed that at low incubation irradiances (PAR 20-30 µmol m^{-2} s^{-1}) the R-phycoerythrin contents of *C. tenuicorne* were significantly, up to three times higher compared to higher irradiances (PAR >90 µmol m-2 s-1). The opposite effect of irradiance was revealed for net photosynthesis of *C. tenuicorne*, i.e., over two times lower net photosynthesis rates at above mentioned low light conditions compared to higher incubation irradiance were obtained. Meanwhile, the use of blue light instead of white in experiments performed at higher irradiances enhanced remarkable the R-phycoerythrin contents of *C. tenuicorne* but reduced the net photosynthetic rates to certain extent. Thus, further optimization of cultivation conditions will be needed to refine the biomass and increase the economic potential of *C. tenuicorne*

Poster Abstracts in Program

A calibrated growth model for optimising the potential nutrient remediation of macroalgae IMTA in South-East Tasmania

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Integrated Multi-Triphic Aquaculture (IMTA) involves the cultivation of one or more extractive species near a fed species to reduce environmental impact. In South-East Tasmania, several native species of macroalgae have been identified as having the potential to remediate nutrient inputs as waste from the salmon industry in an IMTA scheme. A macroalgae growth model has here been adapted to provide more accurate predictions and better inform stakeholders planning for an IMTA future. The model represents three native kelp species: *Macrocystis pyrifera, Ecklonia radiata* and *Lessonia corrugata*. It has been calibrated with field data from recent farming trials. Updated water attenuation and temperature limitation functions have also been added, providing a more realistic estimation of growth conditions in a farm setting. Results of the calibration will be presented along with an exploration of the differing remediation potential of the three species on a large scale given nutrient inputs from both natural and anthropogenic sources. While the model is intended for optimising nutrient remediation, future applications include maximising biomass production potential and planning for the effect of climate change on a future kelp industry.

Production and characterization of fucoidan-active enzymes from *Lentimonas* sp. CC4

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Fucoidans are a heterogeneous group of sulfated polysaccharides found in the cell wall of brown seaweeds and occurring in a wide variety of arrangements. At the simplest, they are composed of α-L-fucose units arranged as an α-1,3-, or an alternated α-1,3;α-1,4-, linear backbone with varying degree of sulfation at carbon 2, 3, and 4. Additionally, fucoidans can be branched, acetylated, and contain galactose, xylose, mannose, rhamnose, glucose, and uronic acids units. Fucoidans have attractive valorization prospects due to several reported biological activities. However, the complex and largely undefined structure of fucoidans is a major challenge in the understanding and further study of their biologically active motifs. Fucoidan-active enzymes, found in many marine bacteria, are classified into different glycosyl hydrolase (GH) families within the carbohydrate-active enzyme database (CAZy). Different types of enzymatic activities have been described, including *endo*- and *exo*-fucoidanases, sulfatases, and carbohydrate esterases, all potential enzymatic tools for processing of fucoidans and for structural elucidation. Recently, the genome of *Lentimonas* sp. CC4, a marine bacterium highly specialized in fucoidan degradation, was sequenced revealing 284 putative fucoidan-active enzymes. In this study, we have carried out a bioinformatical mining of fucoidan-active enzymes from *Lentimonas* sp. CC4. Blasting the sequence of previously described fucoidanases and sulfatases led to the selection and cloning of 4 putative *exo*-fucoidanases, 6 putative *endo*-fucoidanases, and 4 putative sulfatases. All these enzymes have been successfully expressed in *E. coli* and tested on fucoidans from 9 different brown seaweeds using a range of analytical methods

Poster Abstracts in Program

Indonesia Tropical Seaweed: Solution To The World

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As a country with a tropical climate, the area of Indonesia seaweed habitat is estimated at 1.2 million hectares or the largest in the world. Making Indonesia the largest tropical seaweed producer in the world. Seaweed is a gift for the Indonesian people that can be utilized ecologically, economically, and socially to become a driving force for national and global development that is environmentally friendly and sustainable. The Ministry of Maritime Affairs and Fisheries in collaboration with the Tropical Seaweed Innovation Network (TSIN) will showcase a poster in ISS 2023 with the theme "Tropical Seaweed: Solution to The World". This poster aims to demonstrate the development of technology and innovation of national seaweed products, as well as the potential and status of utilization of high-value Indonesian seaweed species, and to facilitate link and match between research and development results with the seaweed industry. Various product innovations and seaweed technology are divided into 4 themes, namely *State of The Art* which is the development of cultivation and processing technology (traditional to advanced), *Frontier* which is the high value potential of seaweed species and other high utilization developments, *Blue Economy*: *The Solutions* which is the important role of seaweed in responding to global issues including innovative products and The Enablers which is the seaweed industry support services: seaweed business, startup, and promotions. This is a medium of synergy and collaboration for stakeholders in advancing the national seaweed industry activity and was made possible thanks to the support of all stakeholders of seaweed.

Eucheuma isiforme cystocarps development at Yucatán coast, Mexico.

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Importance of *Eucheuma isiforme* (*Eucheumatopsis isiformis* (C. Agardh) Núñez-Resendiz, Dreckmann & Sentíes, 2019) in Yucatan region is related to characteristics of carrageenan that it contains, this is a kappa-iota-nu hybrid structure with a dominant iota-carrageenan and high yield, which makes it one of native species of the region with potential for cultivation. Morphological characteristics of *E. isiforme* cystocarps are described from samples collected in field every two months from March 2022 to January 2023. Samples were collected in Dzilam de Bravo and Ria Lagartos and transported to the laboratory for review, characterization, and analysis. Cross-sectional and longitudinal sections were made and characteristics of each specimen in carposporophyte phase were described. From temporal variation it was possible to identify mature cystocarps and observe evidence of sporulation. Maturation seems to be related in the study area mainly to monthly seawater temperature, as well as changes in carrageenan content as a response to sulfation processes. The next step of this research is to use this information to plan *in vitro* sporulation experiments, this would contribute to the knowledge in the cultivation of *E. isiforme* from carpospores. However, research on the genetic information contained in the latter is necessary to know the quality of the cultivated genome in the long term.

Persistent marine bacteria isolated from a closed cultivation system in a culture of *Kappaphycus alvarezii*

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Red algae are commonly cultivated across the world, especially in Asian countries including Malaysia. The red algae, particularly *Kappaphycus alvarezii*, is crucial for biomass production and as a source of revenue for local farmers. Throughout the years, the biomass yield of the seaweed farming industry has been gradually decreased by the ice-ice disease infection. Hence, this study aims to investigate the persistent bacteria associated with *Kappaphycus* seaweeds that adapt in a cultivation system and may be a potential causative biotic agent to the disease. The data provided includes bacterial community profiles on the surface of *K. alvarezii*, which was isolated directly on the first day and after 30 days of cultivation in a closed circulation system. *Kappaphycus alvarezii* seedlings were maintained in a laboratory setting under controlled growth conditions for 30 days to examine bacteria that could adapt to an extended culture duration and perhaps induce biotic stress to the culture. Bacterial 16S rDNA amplification and sequencing were carried out on bacterial isolates associated with seedlings for taxonomic identification. The data reveals a distinct set of microbial changes between day one and day 30. The phylogenetic tree depicts four major clusters that inhabit on the surface of *K. alvarezii: Vibrio, Pseudoalteromonas, Alteromonas,* and *Bacterioplanes*. The comparison of these two bacterial groups provides evidence of the persistent marine bacteria that adapt to long-term culture in closed circulation systems and suggests that biofilm formation may be the first stage of disease colonization and infection on seaweed seedlings.

Effects of temperature, irradiance, and nutrients on gametophyte growth and sporophyte production of *Ecklonia radiata*

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Ecklonia radiata is a kelp species of interest to Australian aquaculture development and while the sporophyte phase has been extensively studied comparatively less is known about the microscopic gametophyte phase, especially regarding interactive effects between temperature light and nutrients. We will produce thermal response curves for gametophyte size (growth) and sporophyte production of *Ecklonia radiata* under two irradiances (60, 120 µmol photons m^{-2} s^{-1}) and two nutrient (Ambient: 3 µmol L^{-1} NO_3-; F/2: 882 µmol L-1 NO_{3-}) concentrations over a temperature range from 4-30 °C. The data is currently being analysed and the results will provide details on synergistic effects between these factors such as shifts in thermal range and optimum under nutrient depleted conditions. This knowledge will further the optimisation of lab culture for *E. radiata* both for aquaculture and restoration purposes.

Poster Abstracts in Program

Offshore cultivation of *Gracilaria cornea* seaweeds for extraction of agar and skin-health promoting substances

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The worldwide supply of agar comes exclusively from a few red seaweed genera and especially from the *Gracilaria* genus, mostly grown in shallow beaches or tide pools (FAO2018). In recent years, red seaweeds have gained further interest as a potential source for health promoting substances, such as antioxidant and anti-inflammatory agents. In our research, we explored the effects of several factors on the growth rates and agar yields of the tropical seaweed *Gracilaria cornea*, grown in a specially designed outdoor tank system, for better control over cultivation conditions.

Our finding indicated that an addition of artificial LED illumination for a period of 14 hours, during the day, significantly enhanced growth rates of *G. cornea*. Surprisingly, a supply of air bubbling—a common, expensive practice in offshore seaweed growth systems—had no significant effect on growth rates when compared to *G. cornea* grown without bubbling.

Additionally, a series of *G. cornea* extractions were verified to be safe for topical application on *ex vivo* human skin explants. Some of these extractions were very potent in reducing the inflammatory response of human skin cells to either air pollution or UVB exposure, in a dose dependent manner.

Overall, our results provide important information for current and potential *Gracilaria* growers seeking to improve their yields while lowering the cultivation costs. Our results also show that G. cornea has a potential commercial value not just as a source for agar, but also as a natural, plant-based source of health promoting ingredients for the skin care industry.

Extending sea-based cultivation season of *Ulva fenestrata* by post-harvest treatment in herring production process waters

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Seaweed aquaculture can provide the growing population with a sustainable source of proteins. Sea-based cultivation is an effective method for farming seaweeds on a large scale and can yield high biomass output. The quality and biochemical composition of the biomass is however seasonally dependent, which limits the harvests to certain periods of the year. This study investigates the possibility to extend the sea-based cultivation season of Scandinavian *Ulva fenestrata*, aimed for food and feed production. We do this by cultivating *U. fenestrata*, harvested at sub-optimal summer period (with regards to its protein content), in herring production process waters as a post-harvest treatment in onshore tank systems. After 14 days, biomass yields were 30 - 40 % higher in the process waters (213.33 – 228.67 g fresh weight (fw)) compared to in seawater (162.67 g fw). The crude protein content increased by 3 - 4.5 times, from 3.76 % to 11.98 - 16.92 % dry weight (dw). Furthermore, the total amino acid composition (15.30 - 20.69 % dw) indicates that the crude protein content conversion factor of 5 underestimates the true protein content of the biomass. We show that the cultivation of *U. fenestrata* in herring production process waters generates protein-rich biomass, following food graded standards for heavy metal content. Additionally, no negative sensory attributes compared to when cultivated in seawater were found. The post-harvest treatment extends the cultivation period of *U. fenestrata* in sea-based cultivations, maximizing the output of sustainably farmed protein-rich biomass.

Poster Abstracts in Program

Differences of ontogenetic development, growth and biochemical profiles in early developmental stages of *Ulva fenestrate*

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Aquaculture of sea lettuces is continuously increasing. The high productivity, wide environmental tolerance, as well as the interesting functional and nutritional properties of *Ulva* biomass are accompanied by its multi-purpose-use in different industrial sectors. The focus of most studies has mainly been on the mature biomass, whereas there is only little knowledge on the ontogenetic development of gametes and spores which are crucial elements for a successful aquaculture.

With our study we investigated how changes in cultivation conditions (seeding density [500, 5000, 10000 swarmers mL^{-1}], temperature [10, 15 °C], nutrients [PES, PESx3]) affect the hatchery behavior and thus the ontogenetic development of two different reproductive stages – gametes (male) and zoids – of Swedish *Ulva fenestrata*. To achieve this aim we conducted two consecutive, manipulative experiments in which we tested if the interactive effects of above named factors had an influence on 1) the early ontogenetic development of gametes and zoids and on 2) the biochemical composition of young thalli of *U. fenestrata*.

We were able to show that young gametophytes obtained from different parental material (sporophytes [zoids] and gametophytes [parthenogenetic developing gametes]) show differences in their ontogenetic development, growth rates and in their biochemical composition (total fatty acid, protein, amino acids, carbohydrate, pigments).

Together, we were able to show that the life stage affects the large-scale cultivability and/or biochemical composition of *U. fenestrata*. Furthermore, our study contributes to the optimization of hatchery cultivation conditions to facilitate a closed life cycle biomass production.

Poster Abstracts in Program

Bull kelp cultivation in Tasmania and New Zealand

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The Blue Economy CRC aims to develop offshore aquaculture and renewable energy systems. Bull kelp (*Durvillaea* spp.) is a strong option for offshore seaweed aquaculture due to its ability to tolerate high wave energy and produce high levels of alginates. However, basic biological information required for the cultivation of bull kelp (reproduction, early life-cycle development and growth, hatchery methods and grow-out requirements) are not known which represents a significant knowledge gap for developing a bull kelp aquaculture industry. This project aims to fill this knowledge gap for four bull kelp species (two in Tasmania and two in New Zealand) and provide the basis to cultivate bull kelp as part of the emerging seaweed industry.

Temperature as determinant factor on spontaneous generation of *Kappaphycus alvarezii* strains cultivated in subtropical waters

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The process of domestication of the seaweed *Kappaphycus alvarezii* (Doty) L.M. Liao has been taking place since 1995 and 1996 with the introduction of a brown tetrasporophyte and a pale brown gametophyte, respectively, in the experimental marine farm of the Fisheries Institute, Ubatuba Bay, São Paulo State, Brazil. From these initial strains, spontaneous strains were generated with different colors. From 2013 to 2022, the occurrence of spontaneous color strains and data of temperature, salinity and water transparency were recorded on the cultivation site. For data analysis, binary logistic regression model was used to identify the significant associations between the presence of spontaneous generation of new strains of *K. alvarezii* (outcome variable) and abiotic data (predictors), and ROC curve was used to investigate the probability of giving rise to new strains. It was observed the appearance of 13 new color strains. The appearance of new brown strains was not observed in this study. Results showed that temperature was significant (p-value 0.025) for generation of new color strains. According to temperature range used in the model, the probabilities to originate a new strain was 7.6% in temperature of 15oC and 0.01% at 33°C. The occurrence of new strains of *K. alvarezii* may contribute to the selection of new cultivars for local mariculture. Financial supports: CNPq, FAPESP.

Aquaculture trial of endangered kelp *Kjellmaniella crassifolia* at three regions in eastern and southwestern coasts of Korea

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To confirm the regional cultivation potential of *Kjellmaniella crassifolia*, a cold-water seaweed, we conducted aquaculture trials in Gangneung, eastern coast, where the kelp had grown naturally in the past, and Seosan and Jindo, southwestern coast, where seaweed aquaculture infrastructure were established. In this results, maximum length growth of thalli observed at Gangneung and Seosan in July as 127.6±6.1 cm and 123.3±32.5 cm, respectively. But maximum length of thalli in Jindo reached 76.0±7.9 cm in June, as shorter than in other regions. Sori fomation of the thalli observed at October only in Gangneung and Jindo. Thalli in Seosan lost due to the rapid erosion after July. Biennial thalli of the kelp obtained only in Jindo, and the growth in the second year (184.6±15.9 cm, maximum 242 cm) was greater than the growth in the first year (76.0±7.9 cm). 10% of thalli in the second year formed sori in July when 3 month early than the first year thalli. Therefore, early seed production and cultivation period elongation could be possible with the second year thalli of this species. In this study, we revealed that Jindo, where cold water mass exist, could be a suitable aquaculture place than any other regions even it was not their original habitat of this species.

Analysis of marine ecological information based on seabed topography

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Due to regional characteristics, marine ecosystem communities, habitat substrates, and marine environment (physical and chemical) are different for each sea area in Korea. Therefore, it is necessary to maintain and manage the marine ecosystem through the conservation and spread of large-scale marine algal communities by scientifically analyzing the habitat characteristics, and marine forests community structure and area by sea area. In this study, the current state of marine forests by sea area was analyzed by examing the exact conditions of marine algae, barren ground coverage of marine forests distributed in each sea area in Korea. The goal is to develop programs related to the conservation of marine forests by analyzing major marine algae, biomass, coverage of barren ground, and the number of herbivores, and to prepare a grading calculation plan for the protection and conservation of marine forests. Currently, basic information on marine forests distributed worldwide, increase or decrease of marine forest area, habitat information, marine ecosystem stability, species diversity and ecological information are very insufficient. Therefore, it is necessary to establish a marine forest protection and conservation management plan with the analyzed data by converting the marine ecological information into a database based on scientific seabed topography information. The marine ecosystem community structure was analyzed based on the substrate coverage data constructed with multi-beam for an accurate understanding of the seabed topography, and with this data, the basic data for technology development and manual establishment that can produce the most efficient eco-mapping for each habitat characteristic constituted.

Habitat status and management plan of Silvetia siliquosa in Korea

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Silvetia siliquosa, a marine alga that grows in the intertidal zone, has traditionally been used as food in the southwest coast in Korea, and has recently been used as a health food and as a treatment for adult diseases such as anti-diabetes, hypertension, and antioxidant. However, the habitat has been gradually disappearing in recent years, and the growing area is being lost, and it has been shown that it is hardly found in the coastal areas adjacent to the land. As a result of reviewing 92 references published from 1913 to 2021 in Korea, 179 habitats were reported, of which habitats were investigated except for habitat loss, missing coordinates, or erroneous areas. In addition, the habitat was extensively surveyed through the surrounding area, and the distribution and current status of the habitat were analyzed. For the investigation, a quadrat (50×50 cm) was installed and distribution characteristics (coverage and frequency) and morphological characteristics (length, width, biomass, maturity) were analyzed. As a result of investigating the distribution and habitat status of 40 *S. siliquosa* habitats identified through literature and surveys, *S. siliquosa* habitat was confirmed in a total of 2 habitats, and all other habitats were analyzed to have disappeared. The biggest reason for the decrease in *S. siliquosa* growth is habitat loss due to anthropogenic disturbance or changes in the marine environment. It is necessary to review the potential for habitat conservation and restoration of *S. siliquosa*, a marine alga with high conservation value, and prepare various countermeasures and action plans.

Poster Abstracts in Program

Assessing Local Adaptation in Macroalgal Microbiomes

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Macroalgae are host to a wide variety of bacteria with which they form chemically mediated relationships, operating as a unified holobiont. Host fitness is often reliant on this symbiosis, with interactions from epiphytic bacteria necessary for the correct physiological functioning, health, development, and resilience of the seaweed. As macroalgae are dominant habitat formers providing a plethora of ecosystem services and commercial benefits, understanding these interactions and how they affect host condition and viability is important not just for macroalgal health, but wider ecosystem and economic functioning. To enhance fitness, seaweeds create a strong selective pressure over the settlement of their microbial community through their chemical structure and metabolites, possibly creating species-specific ecological niches. However, whilst many studies have investigated how algal-bacterial associations shift between species and location, they have not deliberately investigated whether microbial communities are locally adapted. To resolve this question reciprocal transplants via a novel isolation strategy were conducted to test whether a sympatric or allopatric host environment conferred a greater fitness advantage for host associated epibacteria. Transplants were performed on two seaweed species native to Plymouth Sound (UK), *Palmaria palmata* and *Fucus serratus*. Results depicted higher fitness for *Palmaria palmata* isolates in sympatric over allopatric environments, whilst *Fucus serratus* isolates exhibited no difference in fitness between seaweeds. Results confirm that macroalgae may structure their epibacterial community through chemical selection causing epibacteria to become locally adapted. Nevertheless, this ability is variable between species and may be a consequence of differences in epibacterial diversity, chemical structure, and exuded metabolites.

Poster Abstracts in Program

A synthesis of hydrodynamics assessment methods for seaweed dominated shores.

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Wave exposure is commonly recognized in ecology as one of the most influential environmental factors conditioning the distribution and development of coastal seaweeds. Studies relying on a single proxy, either field-measured or derived from coastline topography, to account for exposure, face the risk to produce biased, qualitative and overall poor-quality estimates. We assessed the performance of 8 hydrodynamics proxies (based on biological assemblages, topography, *in situ* measurements, remote sensing, GIS and physical models) along 12 coastal sites of Brittany (NW-France) at four seasons. Mid-shore benthic community structure was described at low tide, revealing the presence of 90 seaweed species and 26 faunal taxa. Two types of mid-shore seaweed communities were identified, either dominated by *Ascophyllum nodosum* or by *Fucus vesiculosus*, clearly distinguished by their canopy-forming and understorey algal and faunal species. Positive correlations were observed between model and GIS-based proxies, while a negative correlation was observed between the biological scale and remote sensing-based proxy. No clear relationship could be highlighted between biological communities and any single hydrodynamics proxy. Hydrodynamics conditions macroalgal communities in two different ways: 1- through local exposure, directly limiting the development of canopy-forming species, and 2- through offshore exposure, which can regulate water bodies characteristics (*e.g.* temperature, nutrients) and consequently the species that inhabit it. Our results suggest that the use of multiple proxies, integrating multiple operating scales, is the most promising approach when trying to account for the complexity of this major structuring factor of seaweed communities.

Shifts in macroalgae composition alters dissolved organic carbon flow in Baltic coastal ecosystems

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The extracellular release of dissolved organic carbon (DOC) from marine macroalgae supports coastal ecosystem function by supplying photosynthetically fixed carbon to higher trophic orders via the microbial loop. Despite its widely acknowledged biogeochemical importance, DOC production is not typically included in production estimates of coastal systems. Additionally, little is known about how changes in species composition and coverage will affect the supply of DOC to coastal systems. Within the context of the Baltic Sea, anthropogenic forces are driving a decline in habitat forming kelp species (*Fucus vesiculosus*) which is superseded by filamentous/turfing algal species, a pattern of change observed globally in numerous aquatic systems. In order to evaluate how this change may impact the flow of carbon within Baltic Sea coastal system, the production of DOC by filamentous algae was examined using high temperature catalytic oxidation methodology in order to determine rates of release. In addition, bioassays were used to assess the lability of released DOC by filamentous algae. This data was linked with macroalgae biomass and coverage surveys in order to determine DOC production as metric of algal coverage and used to evaluate how changes in community structure may impact the flow of carbon within the system. Here we discuss how changes in rates of DOC released by filamentous algae relative to *F. vesiculosus* will act alter carbon flow through the microbial loop. We discuss the impact future filamentous dominated systems will mean for the Baltic Sea in terms of altered carbon flow and how these changes will affect the broader ecology of the system.

Cost-effective methods to observe seaweed ecosystem for blue carbon study

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Recent studies emphasize seaweed ecosystems contribute carbon sequestration as blue carbon. Biomass estimation is important task for blue carbon study. Nowadays sophisticated equipment is available for remote sensing to detect and monitor underwater vegetation with acoustic and optic methods.

Acoustic method includes different type of sonars. Single beam sonar is often used to measure canopy heights. Side scan sonar has wide swath, can cover wider seafloor even in shallow waters. High performance industrial sonars tend to be large and very expensive. Consumers grade sonars are now popular and less expensive, and easy to deploy in the field with compact transducers. In this study we used compact multifunctional, single beam, side scan and down scan sonar with three-in-one transducer.

For optic methods, drones with RGB or multispectral camera are often used. We introduced underwater camera and uplift camera on boat where drone flights are restricted.

We monitored *Sargassum* meadows at small beaches in Sanriku Ria Coast, northern part of Japan. With consumer grade sonar down scan and sides scan sonar images were precise enough to identify underwater objects, but swath widths were narrow due to low emission power. A multispectral sensor drone was easily deployed in the field and got informative image of bottom in shallow water when the drone could fly. Underwater camera and uplift camera were limited in coverage, but always promising monitoring method.

As a conclusion combination of inexpensive optic and acoustic equipment according to the environmental condition enabled us limited but cost-effective and precise monitoring method on benthic vegetations for blue carbon study.

Seascape factors are responsible for the genetic diversity and connectivity of *Ecklonia cava* populations

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Genetic connectivity among marine benthic populations has been essential information for estimating their dispersal capability and the related persistency perspectives. We examined population genetic variability with relation to potential drivers responsible for the genetic clusters of *Ecklonia cava* populations, a foundation kelp species in the northwest Pacific region. We analyzed eleven local populations along with the South Korean coastline from Jeju Island to Ulleungdo, using microsatellite markers. We found that entire populations studied are genetically divided into two groups: inner (south coast populations) and outer (Jeju Island and Ulleungdo) coastal regions, indicating this segregation pattern corresponds to ocean current patterns around South Korea and the geographical topography. Genetic similarity between the two far most populations (Jeju Island and Ulleungdo) provided a possibility that the dispersal distance of *E. cava* could be increased by prevailing current. Inter-population genetic structure in the perspectives of the isolation-by-distance (IBD) and isolation-by-environment (IBE) indicated that distance and turbidity gradient are both contributable factors to gene flow of *E. cava*. However, contrasting results appeared among a few populations, which indicates that effects of these variables could change by geographical range of populations and given oceanographic conditions. This study provides the possibility that gene flow of *E. cava* is driven by multiple seascape factors (ocean currents, coastal topography, distance and sediments), and the interplay among them at a regional scale, which can be applicable to other kelp species with diverse scales.

Poster Abstracts in Program

Effects of indole-3-acetic acid on algal growth of three kinds of Japanese algal family Gracilariaceae

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Interactions between macro algae and attached bacteria have been reported to date. The attached bacteria use the organic compounds secreted by macro algae as sources of nutrition. Some macro algae assimilate vitamins and phytohormones, such as indole-3-aceticacid (IAA), produced by bacteria for algal growth. On the other hand, Japanese species of the red algal family Gracilariaceae are important industrial macro algae, because they have been harvested in Japan as commercial sources of agar and for food additives. They also produce bioactive substances such as enzymes and hemagglutinins. However, details of the environmental bacteria on Japanese Gracilariaceae have never been reported on. Thus, in this study, we investigated the effects of a bacterial auxin, IAA, on algal growth of three kinds of Japanese algal family Gracilariaceae, *Gracilaria vermiculophylla*, *Gracilaria blodgettii*, and *Gracilariopsis chorda*. The effects of IAA on algal components such as sugars, proteins, carotenes were also investigated. Algal components were determined by colorimetric assay and high performance liquid chromatography. Algal apical fragments (each 5 mm length) were cultured in IAA-free medium for 2 weeks and then transferred to various concentrations of IAA-added medium to compare the algal growth rate. Among three Gracilariaceae species tested, the acceleration of algal growth rate by IAA addition was greatest in *G. chorda*. These findings suggest that IAA seems to be useful as an algal growth accelerator

A proposed framework for quantifying regenerative effects of aquaculture in coastal ecosystems

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Globally, there is increasing interest in aquaculture of low trophic species with the combined goals of generating products and generating positive effects on ecosystems. Regenerative agriculture on land, focuses on generating soil fertility, through agricultural practices and assesses success in metrics including soil depth and organic content. Regenerative aquaculture in seawater, is generally associated with ecosystem services that reduce seawater fertility (eutrophication) such as nutrient bioextraction and filtration of particulate organic matter. Those unidirectional processes improve water quality in eutrophic areas but may shift a system toward oligotrophy and deplete plankton populations in less fertile areas. Thriving in a changing climate requires resilience. We suggest additional metrics of ecosystem regeneration to assess the effect of aquaculture on ecosystem resilience, based on system characteristics that promote return from perturbations, or ecosystem recovery. Those include species diversity, network connectance, and dampening variability of production. In practice, measures of spill over effects of aquaculture on local biodiversity, enhanced linkages among species and stability of nontarget population can be metrics of regenerative effects of aquaculture on ecosystem resilience.

Mapping photosynthetic pigments in Antarctic coralline algae (*Tethysphytum antarcticum*) with hyperspectral imaging

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Coralline algae are a diverse group of calcifying red macroalgae (Rhodophyta) that exhibit distinct spectral signatures due to their light-harvesting pigments called phycobilins. Phycobilin quantification is a standard process in coralline algae photosynthesis research, yet it is time-consuming, and can only be measured destructively. In this study, we assess the potential of non-invasive hyperspectral imaging (HSI) in the visible spectrum (400-800 nm), to describe relationships between hyperspectral indices and photosynthetic pigment content of Antarctic coralline algae (n = 14). We validated our hyperspectral images with standard DNA barcoding methods and spectrophotometric pigment analysis. All specimens were identified as *Tethysphytum antarcticum* (Hapalidiales) using the *psbA* marker. Phycobilin extractions displayed peaks in absorbance at specific wavelengths (494 and 564 nm) reported for Antarctic red algae. Accordingly, dips in the reflectance spectral signature obtained with HSI matched the absorbance peaks and overall pigment content. We developed a semi-automated image analysis workflow, to test several hyperspectral indices and their relationship with pigment content. Our results identified the two indices more effective for tracing pigment content in these samples: (1) the double-derivative spectra (563 nm), which had a coefficient of determination (R^2) of 0.7, and (2) the area under the curve (480-520 nm) normalized by max band depth (494 nm), with an R^2 of 0.66. Results obtained in this study help lay the basis for using hyperspectral imaging in red seaweed phycobilin estimates both in lab and field settings.

A Study on the Marine-Physics-Environment research of Marine Forests in the East Sea

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In Korea, Barren ground (sea desertification) phenomenon is centered on the southern coast of Jeju Island and is rapidly spreading to the southern and eastern coasts. The marine forest enhancement project is being carried out to cope with decrease of the habitat and spawning grounds due to the expansion of barren ground phenomenon which affects to seaweeds biomass decrease. The marine forest enhancement project aims to restore the coastal ecosystem. This project includes formation of marine forest, management on enhancing the marine forest, management of a natural seaweed bed, improvement of the site conditions. For selecting the marine forest enhancement project site, the marine physical environment factors should be considered. This study is conducted a survey on the spread of tidal, algae, waves, and floating sand to accumulate data for evaluating marine ecosystem changes. In addition, for strengthen the resilience of the marine ecosystem and conserving the environment, seaweed reproduction induce study is conducted and expected to be used as basic data in the future. The estimation of the range of seaweed spore spread is possible by understanding the movement distance and direction of large brown algae which released from natural marine forests and artificial marine forests. It is expected that this will be an optical site for creating marine forests that can maximize the effect of restoring the marine ecosystem.

Water motion and seasonality in morphology of *Lessonia corrugata*

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Resilience to hydrodynamic stress allows kelps to inhabit a range of environments with different intensities of water motion in space and time. Some species have plasticity in their morphology, allowing them to grow in sites with large hydrodynamic forces, whereas other species cannot. Here, we studied the morphological adaptations of *Lessonia corrugata* (order Laminariales) to different wave exposure levels in Tasmania, Australia. *L. corrugata* was wild-harvested in the autumn and spring of 2021 at three sites (Coal Point, South Arm and Taroona) with different wave intensities and its morphological characteristics measured (length, number of blades, thickness, width, base angle, number of corrugates and stipe length). We found differences in morphology between the three sites: *L. corrugata* had characteristics to reduce drag forces on more wave-exposed sites (e.g. increased length and corrugations and reduced number of blades), and the density of *L. corrugata* individuals within a bed was higher on wave-exposed sites. There was also seasonal variation in morphology. In spring, hydrodynamic characteristics were more apparent due to the higher water motion in that season. Results suggest that *L. corrugata* is well adapted to sites with a high level of water motion, where the competition for space may be reduced due to hydrodynamic stress.

Marine ecosystem restoration through creation of seagrass meadow

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The seagrass meadow which is a primary producer in the marine ecosystem and serves habitat and nursery for marine life is gradually disappearing due to climate change and environmental pollution. In order to implement carbon neutrality in accordance with Paris Climate Agreement, the importance of protecting and conserving seagrass meadow has increased. This study artificially restored seagrass meadow on the west coast of Korea through the "Marine Forest Project". Two seagrass meadow were artificially created in waters of Ongjin-gun, Incheon in 2019 and 2020 and 50,000 shoots of seagrass were transplanted to the site respectively. An effect survey was conducted in accordance with the guidelines of "FIRA seagrass meadow Effect Investigation". The density of seagrass meadow in artificially created and the natural site has increased spring to summer and has decreased in autumn. In 2019, the number and population of marine benthos in the natural seagrass meadow were the highest with an average of 23 species and 539 ind./m2. Artificial seagrass meadow were found 17 species and 363 ind./m2, Control area were found 13 species and 146 ind./m2. In 2020, the number and population of marine benthos in the natural seagrass meadow were the highest with an average of 19 species and 462 ind./m2. Artificial seagrass meadow were found 17 species and 292 ind./m2, control area were found 10 species and 162 ind./m2. Same tendency showed in 2019 and 2020. In conclusion, artificial restoration of the seagrass meadow affected the increase in the number and population of marine life.

Poster Abstracts in Program

Characteristics of marine algal community of intertidal zone in Yeongil Bay, East coast of Korea

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The purpose of this study was to explore the annual changes and characteristics of marine algal community in Yeongil Bay, East coast of Korea. Thirteen sites were selected in the intertidal zone of Yeongil Bay and seasonal surveys were conducted from August 2021 to July 2022. Samples were collected using a quadrat (50×50 □), and species identification and community characteristics were analyzed in the laboratory. During the survey period, a total of 189 species (28 green, 31 brown, and 130 red algae) were identified. The number of species and mean biomass by season were 114 species, 677.46 g/m^2 in summer, 108 species, 556.56 g/m^2 in autumn, 129 species, 1065.75 g/m2 in winter, and 113 species, 1030.95 g/m^2 in spring, respectively. Therefore, both the number of species and biomass were highest in the winter. Species that appeared in all areas throughout the survey period were *Ulva* spp. and *Ahnfeltiopsis flabelliformis*. Based on the mean biomass, *Sargassum thunbergii*, *S. muticum*, *Ulva australis*, *Corallina pilulifera*, *S. yezoense* were dominated. Recently, a marine industrial complex is located near Yeongil Bay, and the pollution level of the coast is increasing due to artificial disturbances such as coastal construction (e.g. Yeongil New Port construction) and the inflow of pollutants. The influx of these pollutants showed that the marine algal community of intertidal zone is being changed by human activities and environmental pollution. Therefore, in order to respond to these changes, ecological restoration with the concept of ecological engineering targeting intertidal marine algae communities can be proposed

The effect of sedimentation on spore settlement and recruitment of the Arctic kelp, *Laminaria solidungula*

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The Arctic is experiencing rapid rates of environmental change due to ramifications of climate change and human development. Changes to the natural environment can enhance the impact of abiotic stressors such as sedimentation from enhanced river discharge, permafrost melt, coastal erosion, or construction activities in Arctic ecosystems. High rates of sedimentation can be detrimental to kelp abundance and distribution, possibly due to increased mortality at the spore dispersal and settlement stage. The purpose of this study is to examine the effects of sedimentation on spore settlement and viability of the endemic Arctic kelp *Laminaria solidungula* through a series of lab-based experiments. We hypothesized that spore settlement and viability decrease under increasing sediment loads. Reproductive *L. solidungula* individuals were collected from the Stefansson Sound Boulder Patch in the Alaskan Beaufort Sea and cultured until the induction of spore release. Spores were exposed to increasing sediment loads in three experimental designs simulating different sedimentation scenarios. Settled spores and developing gametophytes were quantified at the completion of each experiment. Gradual sediment effects on spore settlement were observed. Due to rapid advances of climate change and interest in oil and gas development near well-studied *L. solidungula* kelp habitat in the Arctic, it is important to gain better understanding of how increased sedimentation will affect *L. solidungula* recruitment, and, thus, the long-term persistence of a diverse and productive benthic habitat.

Chemical composition of the three holopelagic taxa of *Sargassum* in the Mexican Caribbean: ecological implications

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Sargassum events in the Caribbean have caused severe socioecological affectations. The knowledge of the chemical composition of *Sargassum* biomass is key to develop potential applications for its biomass, describe the bioaccumulation and release of pollutants, understand the degradation process, determine nutrient limitation/enrichment to explain growth, and ultimately, to discuss about its controversial role to sequester carbonparticularly on coastal systems. Brown seaweeds of the genus *Sargassum* are the largest canopy-forming algae in tropical and subtropical environments, with a wide global distribution on rocky reefs and as floating stands. Because these algae present high amounts of biomass, we suggest their contribution is relevant for global carbon stocks and consequently for mitigating climate change as CO2 remover. We modelled global distributions and quantified carbon stocks as above-ground biomass (AGB. Stranding biomass in the Mexican Caribbean is composed by holopelagic *Sargassum* and benthic macrophytes including macroalgae and seagrasses, whose relative abundance is spatiotemporally variable. Therefore, determining the chemical composition of the species in the strandings is a priority. In this study, we analyzed the monthly chemical composition (dry weight, carbohydrates, proteins, ashes, and C:N ratio) of the three holopelagic taxa (*Sargassum fluitans* III, *S. natans* I and S. natans VIII) which represent up to 99.6% of the stranded biomass in the Mexican Caribbean. Samplings were performed monthly in the north coast of the Quintana Roo state during the rainy season in 2018, when the biomass peak occurred. Monthly differences over the chemical constituents and between *Sargassum* taxa were found. Preliminary results showed that the mean carbohydrate and protein content and, the C:N ratio showed large variation ranging from 13.5-21.8%, 9.1-14.5% and 19.8-29.9% respectively, whereas the mean ash content ranged from 21.2-23.8%. These results are discussed in relation to the monthly differences found in the chemical composition and the relative abundance of the three holopelagic taxa of *Sargassum* for the same time frame and location, including the ecological implications and constraints for its management.

Poster Abstracts in Program

Predicting habitat suitability for the red sea plume (*Asparagopsis taxiformis)* in the Great Barrier Reef

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Asparagopsis taxiformis is a red macroalgae typically found in subtidal zones attached to rocky substrates. Recent interest has increased towards harvesting this seaweed for research and culture technology development as a feed ingredient for mitigation of enteric methane from ruminant livestock. Critical to the sustainable utilization and management of this resource is thorough information on its spatial distribution. In addition, several studies have reported the ability of *A. taxiformis* has also been reported to outcompete corals and therefore an understanding of the current distribution of *A. taxiformis* can inform habitat shifts. Historical records indicate its distribution across the Great Barrier Reef (GBR), Southeast Queensland, and Western Australia. Recently, records of its occurrence in iNaturalist have increased, extending the knowledge on the distribution of *A. taxiformis*. In this study, a preliminary modelling using maximum entropy was conducted to estimate the current broad-scale current distribution of *A. taxiformis* in the GBR utilizing environmental layers from various sources including Qspatial and modelled environmental variables from eReefs. Habitat suitability maps were produced at the scale of the GBR (4 km resolution) and for key areas, for example Gladstone and the Keppel Islands (100 m to 1 km resolution) with an AUC accuracy of > 0.6. Several factors were included in the modelling, with wave exposure as a possible key indicator driving its distribution. Results of this study will be refined further to develop more robust models which can be used to understand better the ecology of *A. taxiformis* and inform resource monitoring and management.

Poster Abstracts in Program

Remote sensing for macroalgal blooms detection: using a new index in Tuggerah Lakes, NSW, Australia

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The excessive growth of macroalgae, or blooms, is a world-wide phenomenon in estuarine habitats and may significantly impact the entire ecosystem by inducing hypoxia, smothering seagrasses, and ultimately leading to the loss of biodiversity. Understanding conditions under which blooms occur requires observations of their temporal and spatial dynamics. One of the challenges of effective monitoring is developing reliable and non-expensive techniques of measuring algal biomass and/or the area of the blooms. The use of satellite images is an effective non-invasive method of observation allowing monitoring at large spatial scales.

In this study, we describe a newly constructed Floating Macro Algae Index for detection of algal blooms using satellite images and compare its accuracy with previously developed algorithms for detecting aquatic vegetation via remote sensing. The detection of algal blooms by the indices using the red-edge effect of the chlorophyll (SAI, FLH, SABI, VB-FAH) result in the most accurate results as verified by algal sampling using drones during the algal bloom at Tuggerah Lakes in South-East Australia.

All studied indices can be divided into two groups. Rough estimation algorithms (TVI, NDVI) determine the presence or absence of algal mats whereas the fine gradation ones (FAI, NDAI, MCI, ABDI) provide a measure of relative quantity of the chlorophyll present. For smaller water bodies such as estuaries the resolution of the sensor is a limiting factor. With further improvements of satellite sensors, FMAI can potentially use a wider range of reflected spectra and allow large scale observations of algal blooms in multiple estuaries.

Elucidating the effect of physical factors on the macroalgal communities over small spatial scales

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Climate change is one of many factors that has led to the transition and decline of macroalgae communities throughout Japan and the collapse of these communities are believed to negatively influence coastal fisheries productivity. Japan has a rich history of transplanting seaweeds, spore bag deployment, and artificial reefs installation to restore and expand macroalgae communities. To maximize the effectiveness of these conservation efforts, information about the relationship between environmental factors and macroalgal communities at small spatial scales is important. We hypothesized that physical environmental factors at relatively small spatial scales (i.e., 100 m) influence the composition of macroalgae communities in Arikawa Bay, Nagasaki, Japan. We conducted field surveys from April 2021 to July 2022 at seven stations that were separated by about 200 m. At each station we recorded the macroalgae species, water temperature, water motion, sedimentation, and water depth. The community matrix of each station was determined and a redundancy analysis (RDA) was performed to elucidate the relationship between the community composition and environmental factors. From the RDA, we inferred that water motion and variations in daily water temperature influences the composition of macroalgae communities. Therefore, we suggest that exposure to wave forces and thermal stress can influence the composition of these communities at relatively small spatial scales.

Poster Abstracts in Program

Seaweed community composition in Arikawa Bay, Nagasaki Japan may be related to minimum winter temperature

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In Nagasaki Prefecture, Japan, economically important large brown seaweeds such as *Ecklonia cava* subsp. *kurome, Sargassum fusiforme*, and *Sargassum horneri*, are rapidly declining. We designed a survey to elucidate the environmental factors that may be responsible for the decline of seaweed communities in this region. We were especially interested in comparing two sites within Arikawa Bay of Nakadori Island, Nagasaki, Japan that were about 3000 m apart. We recorded observations of seaweed species, water temperature, wave action, water depth, and seaweed benthic cover at Kujiramiyama and Naname from December 2021 to May 2022. The species composition of seaweeds during the Spring was distinctly different among the sites. Small brown seaweeds such as *Dictyota dichotoma, Padina arborescens, Sargassum hemiphyllum* and *Sargassum alternato-pinnatum* dominated in Kujiramiyama, whereas large brown seaweeds such as *Undaria pinnatifida*, *Dictyopteris undulata, Sargassum horneri,* and *Sargassum fusiforme* were dominant in Naname. A few individuals of *Ecklonia cava* subsp. *kurome* was also observed only at Naname. Among the environmental variables that were recorded, we noted that the winter minimum water temperatures were up to 1.0 ± 0.89 °C (mean ± sd) lower at Naname. Given the slow increase in mean seawater temperature in Arikawa Bay due to climate change, we suggest that relatively low water temperature allows the large brown seaweeds to persist in Naname. Our surveys continue, with the aim to confirm our hypothesis.

Attached *Ulva meridionalis* on nearshore dikes may pose a new ecological risk in the Yellow Sea

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Global warming and seawater eutrophication are resulting in unstable coastal ecology. Green tides, which have been documented in numerous seawater areas in China, have progressively become a global phenomenon. They are believed to be caused by green macroalgae shedding into the sea. The connection between algal shedding and environmental conditions has, however, barely been studied. The physiological status of algae is significantly influenced by environmental elements such as pH, sea surface temperature, and salinity. Therefore, this study assessed the correlation between the shedding rate and environmental factors (pH, sea surface temperature, and salinity) based on field observations of the shedding of attached green macroalgae in Binhai Harbor. Although there was no correlation between the shedding rate and pH, sea surface temperature, or salinity, the environmental conditions were ideal for the growth of *Ulva meridionalis*. The shedding rate ranged from 0.88% ± 0.11% to 4.78% ± 1.76%. Despite the fact that typhoons and currents may also have an impact on the production of the *Ulva meridionalis* green tides, human activities and seawater eutrophication may be the primary reasons. This study revealed *Ulva meridionalis* may present a new ecological threat in the Yellow Sea.

Poster Abstracts in Program

Predicting the effects of Ocean Acidification on macroalgal communities in coastal areas of the NE Baltic Sea

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The carbon acquisition strategies of aquatic photosynthetic organisms play a key role in the growth and survival of a species. There is much research indicating the predicted changes (e.g., the balance between carbonate species: CO_2, HCO_3–, $CO3_2$–) in the seawater carbonate chemistry, due to Ocean Acidification (OA), could affect benthic primary producers and their communities. So far, too little attention has been paid to what extent carbon availability limits productivity in coastal waters, especially in the Baltic Sea. Perhaps the most glaring hole in our knowledge surrounds the "CO_2 fertilisation effect". There is a need to pay more attention to vegetated coastal ecosystems as they will have an important role to mitigate ocean acidification. The identification of the carbon uptake strategies in macroalgae (i.e. exclusive CO_2 users, and/or HCO_3^- users) could indicate how complicated coastal ecosystems will respond to the predicted changes in seawater carbon chemistry. Few studies have examined the carbon physiology of macroalgae within the context of climate changes in the brackish Baltic Sea. My PhD focuses on macroalgal communities in the brackish water of the NE Baltic Sea. So far, our research has shown that even species growing together in the same habitat may have significantly different carbon uptake mechanisms. Furthermore, the "CO_2 fertilisation effect" accelerates the growth of filamentous fast-growing macroalgae which may enhance indirectly eutrophication, known as one of the major issues in the Baltic Sea.

Poster Abstracts in Program

Structural profiling of fucoidans based on non-enzymatic hydrolysis and mass spectrometry

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Carbon dioxide fixation to glycans by macroalgae is proposed to be a major pathway for carbon sequestration. Complex, anionic glycans secreted by brown algae called fucoidans persist in the environment and assemble into microgels that promote aggregation of large particles, leading to carbon export and sequestration. The complexity and variability of fucoidans has so far challenged our ability to separate and analyse these glycans in the environment. We aim to develop a pipeline based on non-enzymatic hydrolysis and mass spectrometry for high resolution identification of fucoidans in the marine environment. Our preliminary results using this pipeline demonstrate the ability to distinguish fucoidans from different species based on their unique oligosaccharide profiles. Fucoidans were bought or purified from biomass of *Fucus vesiculosus*, *Sargassum fluitans, Lessonia trabeculata* and *Ecklonia maxima* using a combination of autoclaving, filtration, enzymatic digestion and chromatography techniques. Purified fucoidans yielded oligosaccharide fingerprints from oxidative cleavage using the Fenton's initiation toward defined oligosaccharide groups (FITDOG) method (Amicucci et al., 2020). The fucoidans differed in their oligosaccharide profiles in liquid chromatography mass spectrometry, with some features unique to a species' fucoidan and other features distinct in their relative abundances. These reproducible features enable species-specific fucoidan recognition. Application of this method to environmental samples of dissolved and particulate organic matter in the future will allow us to track fucoidan through the marine carbon cycle with high specificity, delineating the contributions of different algae to various pathways for carbon sequestration.

Poster Abstracts in Program

Big Seaweed Search Mexico: using citizen science to address global environmental challenges in the Caribbean

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The original concept of the Big Seaweed Search (BSS) citizen science project aims for anyone to be able to record a set of seaweeds of interest around the shores of Britain, where species are chosen as indicators of environmental change, including increasing sea surface temperature, ocean acidification and the spread of non-native species. BSS has expanded beyond British shores, driving adaptations of the concept in other parts of the world, such as the Big Seaweed Search Mexico (BSSMx) project. In the Caribbean region, the massive inundations of *Sargassum* ('Golden Tides') have been related to increases in seawater nutrients, changes in ocean currents and wind patterns, as well as maritime traffic and tourism activity in the area. These have impacted not only the coastal ecosystems but also the human communities. The BSSMx focuses on pelagic seaweeds since they are the main component of the beach-cast biomass throughout year, mixing with benthic macrophytes that come from local subtidal populations. The recording of changes, based on data collected by non-scientists, in the species composition of the beach-cast biomass and the relative abundance of the species is the basis of this project. Citizen participation is encouraged through an induction/training workshop and guided surveys to obtain data from the different climatic seasons. This presentation will report on the BSSMx, compare with the original BSS concept, outline initial findings and review training and educational possibilities in a time of global environmental challenges.

Climate change threatens the distribution of Chilean kelps

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The kelps *Lessonia spicata* and *L. berteroana* are ecosystem engineers that dominated the Chilean intertidal zone. They support important artisanal fisheries and provide many other ecosystem services and raw materials. As such it is crucial that we assess the impacts of climate change on these species. We use ecological niche modelling to predict shifts in species distributions under different climate change scenarios, assessing refugia, loss, and expansion areas using both, currents, and future distribution, under four scenarios (RCP 26, 45, 60 y 85). The models predicted distributions that were consistent with the current empirical and genetic distributions. The results showed largely spatially isolated distributions between the 2 species but included overlapping distributions in central Chile (30°-33°S). The modelling predicted that the future range for both species would be dramatically affected: *L. berteroana*, distributed from 15°-30°S will shift its distribution with 66.62% reduction, 33.38% refuge, and an expansion of 225 km2. In 2050, only the central Chile area could act as climatic refuges (24°-31°S) with dramatic reduction of northern areas (from Ica-Perú to Taltal-Chile). For *L. spicata*, which are distributed south of 29°S, the model predicts a 54.79% reduction, with a refuge area of 45.21%, and 2,765 km2 of the expansion area. The central-south zone of Chile is predicted to be the best climatic refuge for *L. spicata* (35°-41°S). These results are an important baseline for managing and conserving species under intense harvesting, and future planning for repopulation and restoration, to reduce the vulnerability to environmental fluctuations.

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Chimerism improves higher-temperature tolerance in the Chilean kelps *Lessonia spicata & L. berteroana*

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Kelps forest ecosystems are biodiversity hotspots that provide goods and services worldwide. They are however threatened due to increases in marine heatwaves, ENSO events, and climate change. Chimeric seaweeds are created by coalescence of two or more "parent" plants in a single entity. These chimeric individuals may have a higher tolerance to environmental changes compared to genetically homogeneous organisms. To test whether chimerism improves higher-temperature tolerance in the kelps *Lessonia spicata* and *L. berteroana*, we used genetically homogenous kelp (control) and chimeras (treatment - Patent CL201701827). We created chimeras with strains from the same population to avoid mixing strains. We then incubated plants from each species for 30 days at three contrasting temperatures: a) 12°C, the present mean of Chile; b) 15°C, 50 years projected prediction; and c) 21°C, 100 years projected prediction. We tested how these temperature treatments affected the specific growth rate of the chimeric kelp compared to the homogenous kelp. Our results indicate that chimeras showed a higher growth rate in the three treatments than homogenous controls. This result was independent of the origin or species population. Our results suggest that chimeric kelps have higher thermal thresholds. Therefore, we suggest chimeric kelps as Nature-Based Solutions (Nbs) to restore kelp forests and reduce the vulnerability of kelp forests to ocean warming.

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Poster Abstracts in Program

Genetic structure of remnant giant kelp populations on the Tasmanian coast

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Macrocystis pyrifera forms dense kelp forests creating complex habitats that support coastal productivity and other essential ecosystem services. Tasmanian coasts have lost ~95% of their giant kelp forests in the last decades due to changes in climate and other environmental conditions, such as ocean warming. Recent restoration efforts demonstrated that some lineages of Tasmanian giant kelp possess increased tolerance to warmer waters. Little is known about the genetic structure of these giant kelp populations, particularly warm-tolerant individuals; this knowledge is crucial for building a management plan for kelp forest conservation and restoration. Here, we assess the genetic structure of Tasmanian giant kelp with genotyping-by-sequencing (GBS) and explore whether some genotypes correlate with warmth tolerance. Forty-five gametophyte cultures—originating from parental sporophytes collected at three northern and three southern populations of Tasmania—were used to perform GBS with ddRAD-based library preparation. The individuals from the north and the south are two genetically distinct populations, with genetic divergence also evident between sites within each region, particularly the southeast region. This result contradicts prior genetic analysis (using organellar markers or nuclear ITS), which suggested low genetic diversity among populations in Tasmania. Our results show that ten markers are potentially associated with warm tolerance. However, more genotyping markers were correlated to the absence of tolerance. Our findings reveal a higher genetic diversity of *M. pyrifera* than previously thought and provide an introductory foray to the challenges of using conservation genomics for endangered kelp forests to benefit their restoration and natural resource management.

Exploring the CO2 capture in the kelps *L. spicata* and *L. beteroana* from central Chile

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Kelps are responsible for the carbon dioxide sequestration of coastal marine ecosystems, which is key to climate change adaptation and mitigation. It is also a key factor in developing the blue carbon economy and climate action. To harness the potential of kelps, the Chilean government plans to implement sustainable development strategies. A first key step is to determine the carbon sequestration capacity of the Chilean kelp species. In this work, we studied two allopatric species *Lessonia berteroana* and *L. spicata*, that inhabit the same ecological niche and are also sold as raw materials. We analyzed samples of holdfast and frond tissue from four different localities to estimate the percentage of carbon present. Next, we did a literature review to create a model that represents the dynamics of the carbon capture system in each species. From this review, we identified the existing components, interactions, and missing information. Our results indicate that *L. berteroana* has a higher carbon composition than *L. spicata*. The carbon composition varies depending on the season and tissue type. We found that fronds captured 1-8 times more CO2 than the holdfast. This result suggests that the most used estimates of carbon capture and sequestration may probably overestimate the actual percentages of capture in natural settings. Future blue carbon studies should thus consider these differences to make better projections of carbon stored in tissues, and to generate predictive models that allow for the strategic analysis of nature-based climate action and the potential blue economy.

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Poster Abstracts in Program

A novel approach to measure high throughput thermal tolerance using three canopy-forming kelp species over a latitudinal gradient

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Foundation seaweed species are experiencing widespread declines and localised extinctions due to increases in sea surface temperature. Characterising temperature thresholds is critical for predicting patterns of change and identifying species most vulnerable to extremes. Existing methods for characterising seaweed thermal tolerance produce diverse metrics and are often time consuming, making comparisons between species and techniques difficult, hindering insight into global patterns of change. Using two species: *Phyllospora comosa* and *Ecklonia radiata* across their latitudinal range size – Port Macquarie to Tasmania –, we employed a new method to measure the photosynthetic thermal tolerance of these species acclimated to warm and cold-water temperatures. This new method employs temperature-dependent fluorescence (*T-F0*) curves under heating regimes to determine the critical temperature (T_{crit}), i.e., the breakpoint between slow and fast rise fluorescence response to changing temperature, enabling rapid assays of photosynthetic thermal tolerance using a standardised metric. We found large differences in critical temperatures, with a 10°C difference between populations at their northern vs southern limit, matching the thermal latitudinal gradient and the decrease of heat tolerance with latitude described for animals and terrestrial plants. Temperature-dependent fluorescence curves and their derived metric, Tcrit, may offer a timely and powerful new method for the field of phycology, enabling characterisation and comparison of photosynthetic thermal tolerance of kelp across many populations, species and biomes.

Poster Abstracts in Program

2022 Discoloration of *Pyropia* with the first winter diatom bloom at culture farms of Haenam, Korea

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Discoloration of *Pyropia* by nutrient deficiency in seawater has been occurring periodically in various regions since the first report at 2010 in the western coast of Korea. However, an unusual discoloration event of *Pyropia* observed between end of December 2021 and February 2022 in Haenam, southwestern coast of Korea. Reason of the event presumed to be due to the outbreak of occurrence of large-size phytoplankton *Cylindrortheca closterium* in winter. The phenomenon has serious economic damage about 13 million US$ to the local fishermen and adversely affects the production of the *Pyropia* industry. Korean *Pyropia* industry is a national core one that is moving forward with the goal of exporting 1 billion US$. In addition, it is estimated to be worth about 4 billion US$ due to an continuous increase exports. Therefore, this kind of unusual event could be an obstacle of *Pyropia* industry. In this study, we investigated that phytoplankton density, environmental factors (seawater temperature, salinity, DO and nutrient concentrations) and growth of *Pyropia*. To test recovery of discolored thalli, culture experiment conducted under supplying nutrients. According to nutrient deficiency period, color of thalli was significantly recovered within 7 days. We report that the first occurrence of winter diatom blooms with discoloration of *Pyropia* in Korea.

Poster Abstracts in Program

Quantifying Blue Carbon: kelp contribution to carbon sequestration in marine sediments

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Even with Paris carbon emission-reduction commitments the world faces an average 3.5°C temperature rise (Steer & Reid, 2018). The promotion of kelp-derived blue-carbon sequestration is emerging as an exciting opportunity to mitigate climate change. Kelp beds are the dominant primary producers in the coastal zone, with global production of 28.3 tonnes CO2eq $ha^{-1}yr^{-1}$. High-level estimates suggest approximately 11% of carbon fixed by kelp is sequestered near-permanently (100s-1000s of years) in deep (>1,000m) marine sediments (Krause-Jensen & Duarte, 2016). We are testing this hypothesis with direct data measurement on the Aotearoa New Zealand continental margin, where rich kelp beds and adjacent deep submarine canyons allow export of kelp biomass to the deep sea. We are quantifying the accumulation of kelp-derived carbon in offshore water columns and sediments using a range of techniques including; bulk and compound-specific stable isotopes, eDNA and droplet digital PCR as well as radiometric dating (^{14}C and ^{210P}b). We will utilise a range of endemic NZ kelp species (e.g., *Macrocystis pyrifera, Ecklonia radiata, Lessonia variegata, Marginariella boryana, M. urvilliana, Durvillaea* spp.), focussing on the central Te Tau Ihu Marlborough Sounds and Te Moana-o-Raukawa Cook Strait region. By determining carbon concentrations, age and biological sources in kelp-degradation experiments, sediment cores and filtered water samples, we will establish relationships between coastal kelp-biomass and the quantity and longevity of kelp-derived carbon sequestration. We will interface this information with macroalgae distribution and regional hydrodynamic models to determine high potential sites for kelp-carbon sequestration and perhaps allow blue-carbon inclusion in future markets.

Effects of pH, temperature and light on carbon metabolism in *Macrocystis pyrifera* gametophytes

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The absorption of CO_2 by the oceans is causing a reduction in pH (0.3-0.4 units), a process known as ocean acidification (OA). This, together with changes in the weather variables, impacts marine ecosystems in a complex way. Studies based on large brown seaweed forests show that there is a growing interest in knowing the functioning of Ci uptake mechanisms (CCM) in species such as *Macrocystis pyrifera* who plays a fundamental role as a primary producer in marine environments. The mechanisms of acquisition of Ci described in adult algae could vary from the mechanisms present in other stages of life such as gametophytes, depending on their energy requirements. Previous studies predict that early stages of macroalgae are vulnerable to OA and are considered critical for population survival. However, not many studies address what happens in these stages of their life cycle against environmental factors related to OA and Global Climate Change (GCC). This study evaluated the effect of pH, temperature, and light on the grow/metabolism of carbon in *M. pyrifera* gametophytes. This study included the analysis of physiological variables: growth, photosynthesis, photosynthetic pigments and Anhydrase Carbonic (CA) activity. This study establishes for the first time that the extracellular conversion of HCO_3- to CO_2 carried out by the enzyme CA is the main CCM in gametophytes of *M. pyrifera*. Our results show that the gametophytes of *M. pyrifera* respond in a differential way to experimental conditions of pH/light/temperature and, in general, *M. pyrifera* gametophytes would benefit from future OA and GCC conditions.

Poster Abstracts in Program

Carbon acquisition strategies of Tasmanian red seaweeds (Rhodophyta) and their sensitivity to [H+] and ocean acidification

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The absorption of CO_2 by the oceans is causing a significant reduction in pH (0.3-0.4 units), a process known as ocean acidification (OA). Decreasing pH also alters the seawater carbonate chemistry, changing [H^+], [CO_2], [HCO_3-] and [CO_3-^{2}], each of which can differentially, affect marine ecosystems in a complex way. For most seaweeds, dissolved CO_2 is the main inorganic carbon (Ci) source for photosynthesis, as it readily diffuse into the algal cell. At the current seawater pH (7.9-8.1) CO_2 represents only 1% of the total DIC (Disolved Inorganic Carbon), while 91% is HCO_3-, which cannot passively diffuse through the plasma membrane. Seaweeds (~70%) have developed specialized Ci uptake mechanisms (CCM) to actively aquire HCO3- from the SW bulk and increase the [CO_2] and reduce carbon limitation. However, ~30% of seaweeds do not have a CCM, that is, they exclusively use CO_2 to carry out photosynthesis. Tasmania is globally unique as it has the largest number of non-CCM species reported, especially red algae (Rhodophyta) (90%), but, on the responses of non-CCM species to OA are scarce. The aim of this research is expand knowledge about the mechanisms by which Tasmanian red seaweeds acquire Ci and examine the effects of the different components of the seawater carbonate system (CO_2, H^+, HCO_3-) on their physiology. The PhD is divided into four work chapters: i) CCM determination for red seaweeds, ii) Direct carbon uptake in non-CCM species, iii) CCM modulation by light, iv) Sensitivity to [H^+].

Poster Abstracts in Program

The effects of intraspecifific variation on forecasts of species range shifts under climate change

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As global climate change is altering the distribution range of macroalgae across the globe, it is critical to assess its impact on species range shifts to inform the biodiversity conservation of macroalgae. Latitude/environmental gradients could cause intraspecific variability, which may result in distinct responses to climate change. It remains unclear whether geographical variation occurs in the response of species' populations to climate change. We tested this assumption using the brown alga *Sargassum thunbergii*, a habitat-forming macroalgae encompassing multiple divergent lineages along the Northwest Pacific. Given the phylogeographic structure and temperature gradients, we divided these populations into the southern and northern groups. We assessed the physiological responses of the two groups to temperature changes and estimated their niche differences using n-dimensional hypervolumes. A higher photosynthetic rate and antioxidative abilities were detected in the southern group of *S. thunbergii* than in the northern group. In addition, significant niche differentiation was detected between the two groups, suggesting the possibility for local adaptation. Given these results, we inferred that the southern group may be more resilient to climate change. To examine climate-driven range shifts of *S. thunbergii*, we constructed species- and lineage-level species distribution models (SDMs). Predictions of both levels showed considerable distribution contracts along the Chinese coasts in the future. For the southern group, the lineage-level model predicted less habitat loss than the species-level model. Our results highlight the importance of considering intraspecific variation in climate change vulnerability assessments for coastal species.

Aligning multiple driver research through the Multiple Environmental Driver Design Lab for Experiments (MEDDLE)

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Designing intercomparable multiple-driver experiments is challenging, given the large number of drivers (local, regional and global) and experimental permutations. To help researchers align their experimental approaches, Scientific Committee on Oceanic Research (SCOR) infrastructural project was established: *Changing Ocean Biological Systems: how will biota respond to a changing ocean?*. This project has developed a five-part, web-based Best Practice Guide (https://meddle-scor149.org/), which includes: (1) an electronic book that demonstrates how to break down a complex questions into a suite of simpler experiments, (2) eight video tutorials that explore specific aspects of multiple-driver research (e.g. Developing a Driver Inventory, Experimental Design, and Scenarios vs. Mechanisms), (3) a three-step Decision Support Tool that guides researchers through the development of an experimental design and data analysis plan, (4) MEDDLE simulation software that generates multiple-driver experimental data to explore experimental design and analysis options, and (5) teaching resources that allow easy incorporation of the MEDDLE resources into classes and laboratories. These linked resources help researchers design tractable multiple-driver experiments and will lead to improved prediction of responses to ocean change through better alignment of research efforts.

Poster Abstracts in Program

Species-specific responses of benthic primary producers to the increasing CO_2 environment with potential ecosystem implications involved in the Baltic Sea

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Ocean Acidification (OA) research is primarily focused on the negative implications of elevated ocean carbon on calcifying organisms, while the effect on non-calcifying primary producers has received less attention. Benthic macrophytes vary in their ability to utilize carbon in form of HCO_3– and/or CO_2 for photosynthesis. Some functional groups that are solely reliant on CO_2 for photosynthesis could receive competitive advantages from increasing CO_2 compared to groups that have efficient carbon acquisition strategies of HCO_3–. The aim of this research was to provide species-specific responses of benthic primary producers representing a broad range of traits to the increasing CO_2 environment. Then an extensive habitat mapping data was used to advise potential implications of the elevated CO2 environment to the near coastal ecosystem of the NE Baltic Sea. This study focuses on the most common macrophyte species (macroalgae, charophytes, seagrass, and higher plants) found to inhabit the region. Mechanistic assessment of the carbon physiology of macrophytes was used to predict productivity and competitive interactions between different species under future climate. Carbon use strategies in macrophytes were determined by analysing the natural abundances of carbon isotopes ($\delta^{13}C$), pH drift experiments and photosynthesis vs. dissolved inorganic carbon (DIC) curves. The increasing CO^2 concentrations in the brackish Baltic Sea are expected to enhance the primary productivity of macrophytes. However, changing seawater carbon chemistry has the potential to influence the macrophyte species composition and community structure, and as a result the reduction of habitat-forming species under future climate.

The effects of temperature on populations of the red alga *Gracilaria caudata* from Brazilian coast

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The increase in global temperature has been proving to have an impact on aquatic environments. The thermal limits of a species are determined by its genetics, that is, by its adaptability and acclimation capacity. Genotypic variations related to adaptation can result in populations with quite diverse genetic pools. *Gracilaria caudata* is an agarophyte that occurs on almost the entire Brazilian coast, and therefore subject to great climatic diversity. Thus, questions are raised related to the thermal tolerance of the species and the putative occurrence of ecotypes. We evaluated the effect of different temperatures (15-35°C) on growth rates (GRs), thalli length, and photosynthesis of female gametophytes from four populations distributed along 6,024km of the Brazilian coast: Ceará State (CE, 3.23°S), Bahia State (BA, 12.44°S), Espírito Santo State (ES, 20.48°S) and Santa Catarina State (SC, 27.11°S). The temperature of 35°C was lethal for all of them. BA population showed the highest temperature range survival (15-33°C) when compared to the others (CE, 18-33°C; ES, 15-30°C; SC, 18-30°C). The temperatures that promoted the highest GRs varied among almost all populations (CE and BA, 23-30°C; ES, 25-28°C; SC, 23-28°C). CE population showed the highest GRs (10.85-11.83%), followed by ES (9.80-10.63%), SC (8.28-9.15%) and BA (7.23-9.15%). CE showed higher maximum quantum yield when compared to SC population in almost all of conditions; the farther also showed higher thalli length, and BA and ES showed intermediate values. Our results allow us to affirm that these are ecotypic populations and they may react differently to the global changes.

Poster Abstracts in Program

Potential role of seaweeds in climate change mitigation

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A topical and contentious question is: Can seaweeds' contribution to climate change mitigation be enhanced at globally meaningful scales? There are four categories where seaweed has been suggested to be used for climate change mitigation: 1) protecting and restoring wild seaweed forests; 2) expanding sustainable nearshore seaweed aquaculture; 3) offsetting industrial CO_2 emissions using seaweed products for emission abatement; and 4) sinking seaweed into the deep sea to sequester CO_2. Uncertainties remain about quantification of the net impact of carbon export from seaweed restoration and seaweed farming sites on atmospheric CO_2. Evidence suggests that nearshore seaweed farming contributes to carbon storage in sediments below farm sites, but how scalable is this process? Products from seaweed aquaculture, such as the livestock methane-reducing seaweed *Asparagopsis* or low carbon food resources show promise for climate change mitigation, yet the carbon footprint and emission abatement potential remains unquantified for most seaweed products. Similarly, purposely cultivating then sinking seaweed biomass in the open ocean raises ecological concerns and the climate change mitigation potential of this concept is poorly constrained. Improving the tracing of seaweed carbon export to ocean sinks is a critical step in seaweed carbon accounting. Despite carbon accounting uncertainties, seaweed provides many other ecosystem services that justify conservation and restoration and the uptake of seaweed aquaculture will contribute to the United Nations Sustainable Development Goals. However, we caution that verified seaweed carbon accounting and associated sustainability thresholds are needed before large-scale investment into climate change mitigation from seaweed projects.

Seaweed afforestation at large-scales exclusively for carbon sequestration: Critical assessment of risks, viability and the state of knowledge

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There have been discussions of scaling up offshore seaweed cultivation and sinking it exclusively for carbon sequestration ('ocean afforestation') and thereby help mitigate climate change, but is this concept feasible? Here we investigate the feasibility of ocean afforestation across five perspectives: 1) Ecological feasibility; 2) Technical feasibility; 3) Economic feasibility; 4) Co-benefits and risks; and 5) Governance and social considerations. Optimising ecological factors such as species selection and use of currents, alongside the use of low-cost biodegradable rafts in theory could see this concept scaled globally. An area of 400,000km^2 or 16.4 billion biodegradable rafts of 25m^2 each would be needed for 1 gigatonne of CO_2 fixation. However, CO_2 fixation (calculated from net primary productivity) and carbon sequestration (carbon permanently removed from the atmosphere) are fundamentally different processes, yet this distinction is often overlooked. Quantifying carbon sequestration from ocean afforestation remains elusive given several outstanding oceanic biogeochemical considerations. For example, the displacement of phytoplankton communities and their associated carbon sequestration via nutrient reallocation is a critical knowledge gap. Ocean afforestation also carries complex risks to marine ecosystems, for example, the impact on benthic communities of seaweed deposition. Additionally, governance and social challenges exist such as the legality of operation in relation to ocean treaties. The concept of ocean afforestation is still in its infancy, and while there are large research gaps, further investment into research should be given before the concept can be adequately compared against the suite of potential ocean-based climate change mitigation strategies.

Poster Abstracts in Program

International stakeholder perspectives on implementing multiuse and integration of seaweed aquaculture with other sea uses

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Coastal areas are busy and complex spaces featuring multitudes of human activities, often characterised by rich and diverse ecosystems, and usually subject of overlapping laws, regulations and decision-making systems. Through a management approach that aims to foster synergies between human activities at sea, the concept of multiuse has recently been gaining attraction. Proposing a systematic and participative approach to identifying needs and tailoring strategies of multiuse of marine space, the concept has the potential to enhance sustainable marine space management by ensuring societal benefits, while also mitigating future conflicts revolving around marine resource use and spatial claims.

The present MULTIFRAME project has developed a multiuse assessment approach as a tool to facilitate multiuse for a number of cases (in France, Norway, Brazil, Mozambique, Rhode Island (USA) and Sweden) and seeks to document the development of multiuse in different world regions. Interviews conducted in the late Spring of 2022 across all cases sought to shed light on perceived potential of the concept, with a focus on synergies and challenges of implementation. Notably, the integration of seaweed farming in multiuse constellations is explored in Norway and Sweden. Key highlights include multiuse scenarios, prevalent stakeholder attitudes toward seaweed multiuse scenarios, the global transferability of seaweed centred multiuse solutions, as well as hurdles and possibilities related to practical multiuse development in all case study countries.

Extracted alginate from harvested brown seaweed aid in the fire resistance and acts as a natural binder of biocomposites made for sustainable building materials.

Shimroth J. Thomas - Phycoforms

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Over the last few decades, the construction industry has depleted our natural resources and has become a large contributor to the landfill waste thereby speeding up the climate crisis. Finding nontoxic but replenishable solutions with low embodied energy are crucial for the building industry to allow the sustained growth while still preserving our dwindling resources. With the global population set to reach over 8 billion by 2050 another key factor to consider is land scarcity and the possibilities of embracing the blue economy.

PhycoForms is a biodegradable range of architectural materials derived from the residues of harvested brown seaweed and other waste resources. Harnessing the circular economy framework, extensive material prototyping and testing are carried out using sustainably harvested seaweed and other locally available waste materials to create a fire retardant and durable architectural product. This material exploration investigates the unique properties of alginate present in brown seaweed and how this can be applied to make more resilient and fire-retardant building materials. Lab tests related strength, fire resistance, sound absorption and water susceptibility will be carried out to examine the material properties as compared to existing building materials in the market.

Photosynthetic characteristics of Ulva lactuca by chlorophyll fluorescence from Batangas City under different temperatures

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Ulva lactuca (Ulvophyceae), collected from Cuta-West and Pagkilatan, Batangas City, were subjected under Pulse Amplitude Modulation (PAM) fluorometry to determine the photosynthetic characteristics within different temperatures. Photosynthetic response of *U. lactuca* was measured based on maximum quantum yield (FV/FM), effective quantum yield (ΦPSII), and photoprotective response (*qN*). U. lactuca discs measuring 8 mm in diameter were punched from three individual thalli (n=3). Each sample was tested under 23, 25, 27, 30, and 32 ^{0}C under stable fluorometry reading and continuous stirring. The *FV/FM* of *U. lactuca* collected from the two sites showed no significant difference among the temperatures (p>0.05), implying that these species may have a wide range of temperature tolerance and reflect their possible year-round occurrence. In addition, the ΦPSII of *U. lactuca* from Pagkilatan (p>0.05) displayed higher photosynthetic activity at relatively higher temperatures from 25 ^{0}C to 32 ^{0}C under saturating actinic light levels of 285 µmol photon m-2 s-1. However, samples from Cuta-West did not show significant differences (p<0.05) among these temperatures. This may imply that they are photosynthetically active within a wide temperature range, reflecting their potential to occur all year-round. For *qN*, no significant difference (p>0.05) was found among the temperatures for U. lactuca from Cuta-West, possibly indicating photoprotection in relation with their adaptation to tidal emersion and immersion (high and low temperatures, respectively). Photosynthetic response of these macroalgae is a key component in understanding the physiology of *U. lactuca* under different ecological parameters and in understanding the occurrence of possible green tide blooms.

Temperature does not affect the rate of dissolved organic carbon (DOC) release by *Ecklonia radiata*

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Dissolved organic carbon (DOC) that is released by macroalgae is an intrinsic component of the carbon cycle in the coastal ocean yet knowledge on environmental regulation of DOC release by macroalgae is lacking. Temperature is a critical abiotic factor regulating macroalgal physiology. This study examines the effect of temperature on rates of DOC release and key temperature-dependent physiological traits of *Ecklonia radiata*. Blades were incubated at a range of temperatures (4-28°C) for 14 days and a range of physiological traits were then assessed. There was no effect of temperature on rates of DOC release. Thermal performance curve (TPC) of growth revealed a thermal optimum (T_{opt}) of 15.6°C, a critical thermal minimum (CT_{min}) of 4.3°C, a critical thermal maximum (CT_{min}) of 26.9°C and a maximum rate (r_{max}) of 0.05 g $WW^{-1} \cdot d^{-1}$. TPC of photosynthesis revealed a Topt of 21.8°C, a CTmin of <4°C, a CTmax of 28.8°C and a rmax of 6.7 µmol $O_2 \cdot$ g $WW^{-1} \cdot$ h-1. Chlorophyll a and fucoxanthin content and FV/FM were significantly affected by temperature but did not fit any linear or non-linear temperature response models. The C:N ratio of blades increased with temperature whilst %N decreased and %C was unaffected. This study reveals that whilst temperature was a key factor regulating physiological pathways in *E. radiata*, thermal stress did not affect DOC release.

Comparative transcriptome analysis of wild-type and mutant strains of *Pyropia yezoensis*

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Recently, mutant strain *P. yezoensis* Py2K was generated by gamma irradiation. The strain exhibited enhanced growth and high-temperature tolerance when compared to the wild type. But, the analysis of mutant Py2K was not investigated at molecular level. To counter this problem, genome-wide transcriptome profiling and *de novo* assembly has been extensively employed to investigate multiple characteristics of this species. With the aim of studying the molecular characteristics of Py2K, we performed transcriptome sequencing using RNA-Seq. Based on those data, genes that are differentially expressed can be identified to help to determine the mechanism responsible for the Py500G phenotype. After sequencing, *De novo* transcriptome assembly and redundancy removal generated 167,165 transcripts. The assembly were annotated in NCBI nr, Swiss-Prot, Pfam, KEGG, GO and KOG databases. To unravel the differences in Py2K and wild-type (PyWT), we mapped Py2K and PyWT reads to the assembly and calculated the expression levels. In total, there were 15,979 transcripts that were differentially expressed. Among the differentially expressed transcripts, candidate genes were identified with well-known growth and development functions.

Pyropia tenera (Bangiales) mutant with enhanced temperature tolerance

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A mutant *Pyropia tenera* with improved tolerance to high temperatures was obtained using gamma irradiation. There was selected a mutant Pt1k with improved heat tolerance and different blade colour at high temperatures (20 °C) after an irradiation dose of 1 kGy. The selected Pt1k mutant blades were dark green, which was different from the natural red of the WT. At 12 °C, Pt1k blade growth rate and biomass were four times higher than those of the WT, and phycocyanin (PC) content also increased. When cultured at 20 and 25 °C, blade shapes and growth rates of Pt1k were maintained; however, WT blades were considerably decayed and growth rate was inhibited. When cultured at 25 °C for 3 weeks, chlorophyll a and PC contents were higher in Pt1k than in WT strains, whereas the phycoerythrin (PE) level was constant. These results indicate that the isolated mutant Pt1k had improved growth and tolerance to higher temperatures than the WT.

Nitrogen uptake by *Sargassum siliquosum*: implications for integration into recirculated aquaculture systems

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Farming extractive species such as macroalgae that take up nitrogen (N), with fed species (e.g., lobsters, finfish, prawns) is termed integrated multi-trophic aquaculture (IMTA). In onshore recirculating aquaculture systems (RAS), high concentrations of nitrogenous waste can become toxic to the cultivated species and macroalgae offer a method of mitigating nitrogen waste. To utilise macroalgae as a biofilter for nitrogen waste, an understanding of their nitrogen ecophysiology is needed. Using time-course and multiple flask uptake experiments, we determined the N ecophysiology of the tropical brown macroalga, *Sargassum siliquosum*, to assess its potential use as a biofilter in an onshore RAS with the tropical rock lobster, *Panulirus ornatus*. Uptake of both ammonium and nitrate showed saturating kinetics: for ammonium Vmax =110.9 μmoles g^{-1} DW h^{-1} and K_s = 37.9 μM, and for nitrate V_{max} = 152.7 μmoles g^{-1} DW h^{-1} and Ks = 58.52 μM. Urea uptake was highly variable with both positive and negative (i.e. urea release from tissue) rates recorded; when positive values were considered, V_{max} = 55.5 μmoles g^{-1} DW h^{-1} and K_s = 17.65 μM. We used uptake rates from our study and literature values of excretion rates for by barramundi, tropical rock lobsters, slipper lobsters, mudcrabs and tiger prawns, to determine the stocking density of *S. siliquosum* that would offset ammonium excretion in RAS systems. The findings serve as a reference for future studies on integrating *Sargassum* species into RAS and IMTA systems.

Effect of macroalgal community succession on the ecophysiology of crustose coralline algae: a photophysiological perspective

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Recently, foliose macroalgal communities in temperate coastal ecosystems have been experiencing extreme community succession due to climate and environmental changes. A representative example is the barren habitat, which is affected by top-down and bottom-up control, with nothing but denuded substrate remaining. In barren habitats, as the canopy-forming algae disappear, coralline algae are exposed to various light environments during the phase shift from macroalgal habitats to barren habitats. Thus, we hypothesized that a rapid increase in light intensity due to the disappearance of canopy-forming algae induces photodamage of crustose coralline algae (CCA). To test this hypothesis, an indoor mesocosm experiment was conducted with various light intensities (20, 60, 120, and 250 μmol photons m^{-2} s^{-1}) for 30 days. The growth of the marginal encrusting area and the photosynthesis traits showed that CCA are acclimated to a limited-light environment. Conversely, the encrusting area was reduced and bleaching of CCA was also identified under higher light levels. These results indicate that CCA co-inhabit with canopy-forming algae in environments with sufficient light exposure to support growth and photosynthesis due to the shade provided by the canopy. However, if the canopy-forming algae disappear, CCA will also disappear due to extreme light stress

Poster Abstracts in Program

Spatial variability of phlorotannins extracted from *Hormosira banksii* along a longitudinal gradient in Victoria (Australia).

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Intertidal seaweeds must withstand numerous stresses such as desiccation, temperature, and UV radiation. In temperate Australasian waters, the brown alga, *Hormosira banksii*, dominates the rocky shores. In a place where UV radiation is among the highest in the world, the photo-protection of the habitat-forming fucoid, showing apparent resistance to light stress, was investigated. Photoprotective, and antioxidant, phlorotannins are known to have a significant role in brown algae. Nevertheless, their content is highly variable. To assess the variability of phlorotannins along a longitudinal gradient of temperature and UV index, low and high shore samples of *H. banksii* were collected from two sites within each of four regions (Southwest Victoria, Great Ocean Road, Mornington Peninsula and Port Phillip Bay) in Victoria, Australia. The total phenolic content (TPC) was assessed, and the antioxidant activity was estimated using DPPH (2,2-Diphenyl-1-picrylhydrazyl) radical-scavenging activity and compared with acidic potassium permanganate chemiluminescence measured by post HPLC (High Pressure Liquid Chromatography) separation. Significant variability was observed between sites but was not correlated to temperature and UV index. In fact, this may result in the interaction of various factors including some that were not primarily considered, such as wave-exposure. Moreover, some sites (especially sites within the Great Ocean Road region) revealed very high phenolic content and related antioxidant activities. The high phlorotannins contents discovered in this study suggest a real potential of *H. banksii* for commercial applications, but this also underlines the importance of understanding better what drives spatial variability, and how to sustainably source biomass.

Cross-tolerance induction in *Pyropia yezoensis* to improve resistance to pathogenic oomycetes

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Pyropia yezoensis is tolerant to extreme desiccation and low temperature stressors and thrives in a highly dynamic intertidal environment. These characteristics have been exploited by sea farmers to create cryopreservation method that incorporate drying and freeze processing. Cryopreserved cultivation nets are used in around 20% of *Pyropia* aquaculture today, but studies on the connection between cryopreservation-induced abiotic stress and disease-induced biotic stress is lacking. In this study, we investigated response of *P. yezoensis* to combined drying and freezing stresses and their impact on the incidence of the oomycete diseases (*Olpidiopsis* and *Pythium*). When *P. yezoensis* thalli were immersed in seawater and frozen (-20 °C), only a few cells (<5%) survived after thawing, whereas more than 90% of cells survived when the thalli were treated to drying prior to freezing as in cryopreservation method. The infection rate as well as the progress of oomycete diseases were reduced after cryopreservation treatment to less than half that of the control. The pretreatment with cryopreservation induced the continuous regulation of *HSP* genes that response to infection of oomycete diseases. These results suggest that the proper drying and freezing methods can induce cross-tolerance to biotic stress in *P. yezoensis*, and cryopreservation as aquaculture technology can be useful as a treating measure for oomycete diseases.

Photosynthetic activity and pigments composition of *Adenocystis utricularis* (Ectocarpales, Phaeopyceae) along a latitudinal gradient in the Antarctic Peninsula

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West Antarctic Peninsula has been affected by the increase in temperature in terrestrial and marine ecosystems. Consequently, changes have been observed in environmental variables such as light intensity, temperature, salinity and turbidity, those changes force macroalgae to adapt ecophysiologically to survive. The present study evaluates the effect of environmental variables and the ecophysiology of *Adenocystis utricularis* along a latitudinal gradient on the Antarctic Peninsula. Adult individuals (n=7) were collected in 8 sites along a north-south latitudinal gradient (62° to 67°S) on the Antarctic Peninsula, during the summer of 2022. Photosynthetic (ETR*max*, α and E_k) and pigment parameters (Chl a, Chl c and Fucox) were obtained. Results showed significant differences among sites. In addition, a negative correlation was observed between the ETRmax and Ek variables and the latitudinal gradient, these variables decreased from sites of lower to higher latitude. The variable α had a positive correlation with the latitudinal gradient, increasing significantly from lower to higher latitude sites. Photosynthetic pigment concentration showed significant differences only for Chl a and Chl c among sites. Finally, Fucox showed a negative correlation with latitudinal gradient, decreasing significantly from lower to higher latitude sites. These ecophysiological variations are influenced by local environmental factors, which are increased by climate change. Therefore, the species *A. utricularis* must be strategic in its spatial distribution and efficient in light uptake, and in this way to adapt and survive these extreme conditions.

Season regulates flux of dissolved organic carbon from a temperate seaweed forest

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Fluctuations in seasonal abiotic factors such as inorganic nitrogen availability, irradiance and temperature control the growth of seaweeds on temperate reefs. In response to seasonal growth patterns, dissolved organic carbon (DOC) release by seaweeds is also thought to be driven by season. To explore this, we seasonally surveyed, and sampled, the seaweed assemblage at Coal Point on Bruny Island over a one-year period. Seaweeds from phyla Ochrophyta (*Ecklonia radiata* and *Phyllospora comosa*) and Rhodophyta (*Lenormandia marginata, Plocamium cirrhosum* and *Hemineura frondosa*), with various inorganic carbon uptake strategies, were used for laboratory incubations to determine release rates of DOC. Seasonal in situ seawater temperatures were maintained for the experimental incubation and irradiance was kept at 150 μmol photons m-2 s-1 across all seasons. Significant DOC release was observed for every species during spring and summer that were ~400% greater than those observed during autumn and winter. For each season, we calculate a net DOC flux from the reef at Coal Point which supports the microbial food web in this temperate region. The biomass of the seaweed assemblage did not change over the year suggesting fluctuations in the DOC flux of the seaweed bed were driven by seasonal changes to the seaweed physiology rather than amount of seaweed in the reef. Carbon and nitrogen percent dry tissue content and C:N ratios supported our results that seasonal seaweed physiology drove fluxes in DOC release.

Poster Abstracts in Program

Research progress on the CO_2 concentrating mechanism of *Ulva* sp.

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Many algae respond to the limitation of CO_2 in seawater by inducing CO_2 concentrating mechanism (CCM) and obtain enough inorganic carbon to meet their photosynthetic needs. *Ulva* sp. as the dominant species of the large-scale algal bloom disaster of green tide, its thick floating pad is bound to be strongly restricted by inorganic carbon, and it must have evolved a variety of carbon acquisition strategies, such as CCM, to cope with this limitation. In this paper, the existence of CCM in *Ulva prolifera* was confirmed by experiments, and based on this, the position and function of the important components of CCM (carbonic anhydrase, Rubisco and pyrenoid) in CCM were briefly summarized. Several indexes to measure and quantify the relative function of CCM in macroalgae and their applications were introduced in terms of CO_2 affinity of photosynthesis and Rubisco, carbonic anhydrase inhibitor, the use of bicarbonate as photosynthetic substrate and the change of affinity for external inorganic carbon based on the change of inorganic carbon supply. The paper also summarizes the different response mechanisms of *Ulva* sp. CCM under different carbon sources and the related genes that may be involved in the operation of CCM mechanism. These results show that the study on the CO_2 concentration mechanism of *Ulva* has certain theoretical and practical significance and can provide a theoretical basis for the subsequent explanation of the dominant position of *U. prolifera* in the green tide.

Allelopathic effects of macroalga Gracilaria salicornia on the regulation of growth and metabolism of Phaeodactylum tricornutum

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Allelopathy has been proposed as a key mechanism mediating macroalgae–microalgal interactions. In this study, we examined the effects of leaching solution extracts from the marine macroalga Gracilaria salicornia on microalga Phaeodactylum tricornutum under various exposure conditions. G. salicornia inhibits growth and biomass accumulation of P. tricornutum in a dose-dependent manner. Gracilaria has a markedly impacts on photosynthesis efficiency of P. tricornutum. Cell mortality of P. tricornutum increased considerably with increasing concentrations of Gracilaria extracts. Further, the lipid content declined continuously with increasing exposure time, with the maximum decrease up to 93.6%. Reactive oxygen species (ROS) was also found to mediate the allelopathy, which mostly destroyed membranous structures of organelle, and broke cellular homeostasis, further suppressed the resilience of cell viability. The results indicate that macroalgal allelopathy effects are highly dependent on macroalgal dose. Oxidative stress caused by ROS mediates the allelopathy. Endomembrane system injury disrupts cellular homeostasis which potentially affects photosynthesis and metabolic network, thereby limiting the growth of P. tricornutum.

Poster Abstracts in Program

Occurrence of *Asparagopsis taxiformis* in Bulusan, Sorsogon Philippines: A new record

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Asparagopsis taxiformis is a typical tropical to warm temperate red seaweed which abounds throughout the tropical and warm-temperate parts of the Atlantic and Indo-Pacific. Lately, this red seaweed has boosted a renewed scientific, media and commercial interest mainly because of the discovery of its properties as a potent methane release inhibitor from ruminant animals.

A. taxiformis has limited distributions in the Philippines. The discovery of occurrence of this seaweed in Dancalan, Bulusan, Sorsogon is something worth reporting for the first time. The thalli were found attached from sandy to hard substrate by rhizoids with the presence creeping, harpoon-like barbed branchlet at the upper intertidal and in tide pools (1.5-2m deep during the lowest tide). The erect branches (6-10cm tall) is composed of a central terete axis that give rise to densely arranged feathery or plumose branches which comprise of numerous fine, delicate, and densely determinate branchlets that are disposed around an axis. The cystocarps were spherical (6-8 µm in diameter) in shape attached to the main branch by a slender stem (4-7.5 µm long) while the antheridia were cuneiform in shape (4.5 - 5.7 µm long). Released spores from the cystocarps ranged from 0.8 – 1.1 um x 0.3 - 0.4 um in size. Both female and male reproductive structures were found on the same plant from March to June.

These preliminary findings will shed more lights on the understanding of the biology of *A. taxiformis* which may lead to its possible cultivation.

Poster Abstracts in Program

Uncovering the macroalgal flora of Rangitāhua/Kermadec islands (New Zealand).

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Rangitāhua/Kermadec Islands are a subtropical volcanic archipelago situated in the South Pacific Ocean, halfway between New Zealand and Tonga. Rangitāhua hosts New Zealand's largest marine reserve and is considered one of the most pristine ecosystems on Earth. The macroalgal flora, still not fully described, has strong affinities with other warm-water regions of the Pacific and Indian Oceans. Of 157 species previously recorded, more than half are not found in New Zealand mainland. In November 2021, the first expedition to the islands as part of a five-year research programme, Te Mana o Rangitāhua, enabled targeted macroalgal collections associated with different habitats. The programme is led by Ngāti Kuri, (iwi (tribe) with mana moana) and Auckland Museum, and through a holistic approach combining indigenous knowledge and science, aims to understand the biodiversity and ecosystems of Rangitāhua from land to sea and identify indicators of ecosystem change.

Preliminary investigations, with over 160 samples sequenced, uncovered both new taxa, and new understanding of genera and species already recorded. For example, samples identified in the field as *Coelarthrum* or *Botryocladia*, genera with a very distinctive morphology, as well as some samples of turfing red algae, do not align with available data for currently recognised genera. High diversity has been found in the red algae Nemaliales and crustose coralline algae, in the brown algae Dictyotales as well in the green algae. The process of naming the new taxa is bringing together taxonomists and iwi and it will be guided by mātauranga Māori (Māori knowledge).

Poster Abstracts in Program

Unravelling cryptic diversity in *Porolithon*, one of the most important reef-building coralline algal genera

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Porolithon is a major reef building coralline genus in the shallow tropical to subtropical coral reefs. *Porolithon* species provide important ecosystem functions such as cementing and consolidating reef frameworks, providing food and habitat for a range of reef organisms, and facilitating settlement of coral larvae and other invertebrates. Thereby, discovering and documenting the taxonomic diversity of *Porolithon* species is vital to improve our understanding their ecological roles and overall marine biodiversity. In recent years, DNA sequencing studies focusing on this genus have unravelled several striking cases of cryptic diversity. In the largest coral reef ecosystem of the world, the Great Barrier Reef (GBR, Australia), however, no detailed taxonomic studies have been undertaken. The aim of this study was to document the diversity and distribution of *Porolithon* species using molecular and morpho-anatomical data. The molecular analyses using *psb*A and *rbc*L genes revealed extensive cryptic diversity with at least 30 *Porolithon* species occurring in the GBR and adjacent coral reef regions. Our study emphasises the importance of detailed observations of specimens *in situ* (e.g., documenting coloration with a photographic record) coupled with genetic sequencing of the specimens. Our study indicates considerable speciation of this algal genus in tropical and subtropical waters.

Poster Abstracts in Program

Revealing microbiome diversity of natural phytoplankton communities

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The phytoplankton and its' constitutive microbiome have complex and dynamic inter-relationships, that may play a key role in driving the Earth's global biogeochemical systems. Microbiomes colonise both the surface and micro-region around phytoplankton cells (the phycosphere). Both laboratory and field studies show that specific, active microbiomes are essential for phytoplankton growth, and are distinct from the much more abundant "background" microbial community. Despite their apparent importance, we currently know very little about the diversity, structure, and function of natural microbiomes. Using phytoplankton fluorescence characteristics, we aimed to identify and sort individual phytoplankton species and their surface-associated microbiomes directly from natural samples using a MoFlo Astrios EQ flow cytometer. To date we have successfully sorted the dinoflagellates *Tripos furca* and *Gymnodinium catenatum* from multiple natural phytoplankton blooms. Using this method, we have reliably sorted up to 500 cells of the same species multiple times with the same or different samples. Here we compare microbiome diversity obtained by direct microbial profiling (16S rRNA, Illumina) with the culturable microbiome recovered from flow-sorted dinoflagellate cells using traditional isolation and sequencing approaches. Both methodologies demonstrated differences in the community composition between the background environmental flora and the targeted phycosphere microbiome.

Developing a DNA barcoding framework for a coral larvae super inducer, the coralline red alga *Titanoderma*.

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Due to anthropogenic and natural pressures, coral reefs have experienced a significant decline in coral cover since the 1980s, and this has prompted considerable interest in coral reef restoration science. A research topic in reef restoration focuses on understanding the interactions between coral larvae and their preferred settlement substrate, the crustose coralline red algae (CCA). Among the CCA, the genus *Titanoderma* has been identified as an important coral larvae inducer across a range of coral species. The morpho-anatomy of members of this genus is relatively simple with limited variability in taxonomic characters, consequently, researchers struggle to differentiate potential species. The problem of taxonomic identification is exacerbated by the extensive cryptic species diversity within coralline algae. DNA barcoding is a proposed system for species identification, but there is limited knowledge on the best genetic markers used in the identification of *Titanoderma*. Therefore, as part of my Honours project, four gene regions will be compared to determine which of the following markers, rbcL, psbA, COI-5p, and SSU is the most suitable genetic marker for tropical and subtropical, coral reef *Titanoderma* specimens. The material used in this research comes primarily from the Great Barrier Reef. Altogether, this work aims to contribute to the conservation of coral reefs by providing a framework for the rapid, accurate, and cost-effective identification of key macroalgal species that are ecologically important for coral reefs and of significant value in reef restoration.

Poster Abstracts in Program

Diversity of Macroalgae at the Intertidal Zones in the Selected Islands in Antique, Philippines Based on Habitat Characteristics and Survey of Molecular Sequences Available on Online Databases

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The study aimed to assess the diversity of macroalgae of the intertidal zones of Sibato Island, Malalison Island, and Nogas Island in Antique, Philippines. One time sample collection was carried out from January to May 2019. Identification of the samples was done using the observable morphological characters. A total of 56 taxa were recorded including 22 Chlorophyceae, 11 Pheophyceae and 23 Rhodophyceae. Furthermore, 20 taxa of macroalgae are added as new records for the Panay Region, i.e., 12 in Rhodophyceae, 3 in Phaeophyceae, and 5 in Chlorophyceae. Among the three islands, the island barangay of Sibato documented the greatest number of taxa (48) while Nogas Island recorded the least (18). Such result may be attributed to Sibato Island having the largest estimated tidal area, the diversity on the types of substrata and as sheltered by coves and/or sounds from strong wave actions. *Chaetomorpha aerea, Cladophora glomerata, Padina australis, Hydroclathrus clathratus, Turbinaria ornata, Palisada perforata, Amphiroa fragilissima and Gracilaria salicornia* were observed to be the commonly found algal species amongst the three localities. Sites that are neighboring and are subjected to similar environment conditions have higher similarity in terms of macroalgal composition. Species of *Caulerpa, Codium, Dictyota, Sargassum, Turbinaria, Asparagopsis* and *Halymenia* are commonly enountered on sites with stable substrata while species of *Halimeda, Boergesenia, Valonia, Ulva, Hydroclathrus, Actinotrichia, Amphiroa*, and *Palisada* were seen on sites with unstable substrata. A survey was also conducted to determine availability of molecular sequences on online databases that would facilitate alternative and complementary approach to modern taxonomy.

Understanding the influence of genetic and environmental factors on growth and anti-methanogenic activity of *Asparagopsis*

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The use of *Asparagopsis* as a feed additive is currently limited because farming is still in a developmental phase. However, commercial production has significant potential if the life cycle can be closed and selective breeding can occur. Understanding variation in key traits (growth and bromoform concentration) amongst natural populations is the first step toward developing a breeding program. In addition, the relative contributions of genetic and environmental variation (i.e. GxE interactions) also need to be understood. This paper aims to identify new strains of fast-growing *Asparagopsis taxiformis*, assess relationships between genetic variation and growth, and evaluate any trade-offs between growth and bromoform production. The initial focus of this work is identifying which lineages of *A. taxiformis* are present on the Sunshine Coast, Australia, with early evidence that the population is dominated by Lineage 6. The natural history of *Asparagopsis* at this site will be quantified, with gametophytes first emerging in winter (July), with reproductive maturity from September with a peak in December, where cystocarps (containing the carposporophyte) are prominent on females on the shallow rocky reef. Individual carposporophytes will be isolated from female gametophytes and the carpospores collected and germinated into sporophyte cultures. These sporophytes will be assessed using molecular barcoding and evaluated for growth and bromoform concentration. The relationship between bromoform concentration in the source female gametophytes (typically 5-10 mg/g) and the resulting sporophytes in culture will be presented. Together these works provide the foundation to evaluate the best strains for future culture development.

Abstracts

William Henry Harvey and his Australian Seaweeds

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The Irish botanist William Henry Harvey visited Australia in 1854, for the express purpose of 'exploring the natural history of the southern coasts of that continent' and 'extensively collecting Marine Algae'. During his stay in Australia Harvey gathered some 20,000 specimens, representing about 600 species and including many new to science, which formed the basis of what was to become his most significant contribution to the study of Australian seaweeds, the five-volume 'Phycologia Australica' (1858-63). These lavish volumes include colour plates of 300 species of Australian algae, and to this day they remain important references for students of Australian marine algae. Harvey was both the artist and lithographer of the plates included in these volumes. The accuracy, detail and sheer beauty of his illustrations has meant their appreciation endures to this day, and they have been reproduced in numerous books. Despite the over 150 years since Harvey's monumental contributions, and numerous taxonomic investigations by eminent phycologists such as Bryan Womersley, some of Harvey's species remain poorly known, particularly in what Harvey termed the 'Callithamnia', the small, filamentous red algae that were not represented by fertile specimens in his collections. As noted by Womersley (1996: 233), these 'must remain doubtful'. Most of these mystery species were originally collected in Western Australia, and I have endeavoured to recollect, morphologically and molecularly characterise, and propose defensible generic reassignments for this suite of species, the results of which will be discussed in my presentation.

Rimurimu - Seaweeds of Aotearoa New Zealand – the journey of discovery continues...

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Rimurimu – seaweed – is prized by Māori who use various species for food as well as rimurapa (bull kelp – *Durvillaea*) for storage. The first European explorers to collect and describe New Zealand seaweeds visited the region in the late 18th century. It was a further century until there were resident botanists working on macroalgae. The New Zealand archipelago extends from Rangitāhua (Kermadec Islands) at 29° in the north, to Motu Ihupuki (Campbell Island) at 52.32°, the southern of our subantarctic islands. This latitudinal range, the water masses in the region, and our long isolation from other land masses, all have contributed to a diverse and intriguing flora. In the past two decades there has been a very significant increase in the discovery and documentation of New Zealand rimurimu. But much remains to be done - when assessed in 2019 for the New Zealand Threat Classification System, fully 65% of the macroalgal flora was categorised as being data deficient. Detailed integrative systematic investigations (using molecular tools and morphological and anatomical studies) of particular orders and families have revealed much greater diversity than previously recognised (e.g., Dictyotales, Bangiales, Kallymeniaceae, Halymeniales, Corallinophycidae). Important new collections have been made from particular regions (e.g. Hauraki Gulf, Fiordland, Stewart Island, and the New Zealand subantarctic islands), and collaborative research with Ngāti Kuri is addressing naming of rimurimu from Manawatāwhi and Rangitāhua. Much diversity remains to be discovered and documented.

Abstracts

Future proofing kelp forests

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Climate change is causing widespread habitat deterioration and destruction and presents one of the biggest threats to species and global ecological function. Underwater kelp forests underpin fisheries and vast economic values on temperate coasts but are declining due to climate change. There is an urgent need to develop novel and proactive solutions to combat, reverse and prevent this habitat loss. I will discuss how genomic data is providing the evidence we need to assess vulnerability of kelp forests and "future-proof" management under climate change.

Abstracts

Contributing to the seaweed revolution: an overview of the cultivated red seaweed market, its challenges and vision to support the development of a sustainable supply chain – the case of Nosy Boraha Seaweed – Sainte Marie / Madagascar.

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Over the recent years, interest for seaweed significantly grew up. On the other hand, market for cultivated red seaweed has been in a turmoil. In the major producing countries, despite historical high prices, structural issues prevented strong recovery of supply keeping market tightness and slowing down potential development seaweed can offer.

For the seaweed revolution to occur, sustainable production is a key component and consistent supply should be there.

This is not today's reality! Indeed, for cultivated red seaweed, such as *Kappaphycus sp.* or *Eucheuma denticulatum*, current practices and fragmented supply chain are not supporting the conditions to sustain and expand production. Rather, it creates significant pressure on smallholder's farmers shoulders, forced to adopt an opportunistic approach to limit their risks.

A clear shift is necessary to turn around current supply chain, sustain and grow production and accelerate the development of new markets thanks to seaweed great potential.

We are implementing, in Madagascar, an aquaculture model where risk management, modern thinking and social dimension drive our decisions and the way we shape the activity.

The result of this approach is a disruptive model combining craftmanship, improved or novel cultivation techniques, technology, research, multiple collaborations, and proximity with coastal communities we are working with. We believe this model is fair and will handle better future turbulences. We also think it is an attractive option for all and could serve as a reference for future developments and deserves to be shared to contribute to the seaweed revolution.

Abstracts

Commercialising seaweed extracts

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As the world comes to terms with climate change there is a new focus on the role of seaweed to create resilience in food and feed systems. Where will increased volumes of cultivated seaweeds end up? The commercialisation journey from 'proof of concept and a pile of seaweed' to actual products will be illustrated with some real-world examples, with a focus on 'bioactives'.

'Bioactive' seaweed extracts have markets in higher value applications- supplements, medical devices, cosmetics, pharmaceuticals- or even in agricultural feed supplements. Each sector requires a bespoke approach to overcome barriers to entry including regulatory requirements.

Protecting the IP is a core principle. Growers, processers, manufacturers and retailers all need to consider source, process, scaleability, sustainability, regulations and market. Choosing investors wisely, sufficient capitalization and minimizing risk are then critical to success. Should you commercialize solely the technology for a process, application or compound? Is your business fully vertically integrated from growing through to selling retail products, or in the business-to-business space? Case studies will be discussed.

Abstracts

The Kelp Forest Alliance: A Global Home for Kelp Forests

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Local kelp forest restoration projects now span 16 countries and number in the hundreds. These projects are in response to noted declines of kelp forests around the globe and the desire to restore the benefits provided by kelp forests. However, our recent review shows that most projects have not succeeded in achieving this goal. Further, local projects are hindered due to a lack of available information and funding remains low as kelp forest restoration has not gained a large international profile. We have founded the Kelp Forest Alliance (KFA) to help address these problems. The KFA brings together persons and organizations (currently > 300) working on kelp forest ecosystems and aims to enhance the protection and restoration of these valuable ecosystems. In collaboration with the Nature Conservancy in California we published the first kelp restoration guidebook. This document walks helps new projects get started with the best available knowledge. Our restoration database allows users to upload information about new projects and effectively tracks the progress of global restoration efforts whilst ensuring that information will be spread easily. Restoration is a big goal, and we need a big ambition. We are hosting a kelp restoration summit to set a global target for restoration, raise the profile of kelp forests, and inspire new pledges to be made. As we grow, we are looking to build member participation, create new research working groups, provide the relevant information for kelp forest restoration, and promote the restoration of our underwater forests on the global stage.

Abstracts

Norwegian Kelp Forest Restoration

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The extensive kelp forests between 58 and 71ºN along the Norwegian coastline have suffered greatly from sea urchin grazing since the 1970-ies (Mid and North Norway) and from turf/ filamentous algal competition (South and Vest) the last 20 years. The first restoration effort was hammering sea urchins around a small island in 1988, giving the opportunity for a dense kelp recovery already in 1989. Despite this promising result and many proposals, successful sea urchin removal actions were not initiated until about 2005: two experiments with artificial reefs, three experiments with quicklime, one experiment with exclusion in cages, and some transplants of adult kelps. By the same time some very small efforts were tried in the turfing areas; transplants of juvenile and adult kelps, scraping of turf and sediments. Many methods seemed to be promising, but as long as the environmental conditions favored sea urchins and turf in their respective areas, the restored kelps were of limited duration. One exception is the large scale (70 hectare) quicklime experiment initiating a large-scale and lasting kelp recovery and with further expansion due to sea urchin predation by crabs. This is in accordance with an even more large-scale natural kelp recovery initiated by increasing crab populations reducing sea urchins. A starting Norwegian restoration effort is initiated by commercial harvest of sea urchins by newly developed methods (mainly baited traps) accompanied by voluntary groups (kelp watchers, ecotourism). There, new kelp beds are now appearing (2022). Continuous removing of sea urchins will compensate for the (so far) lack of sea urchin predators in this area.

A Review of Tools and Approaches to Restore Northern California's Vanishing Kelp Forests

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California's iconic kelp forests are one of the defining features of the California coastline, and they are at risk of disappearing. Bull kelp (*Nereocystis luetkeana*) is the foundation species of the nearshore kelp forest ecosystem along California's North Coast (Springer et al. 2010). Beginning in 2013, a marine heatwave triggered a number of stressors, including the die off of a sea star species and the subsequent outbreak of the purple sea urchin population. This led to unprecedented declines of over 96% of bull kelp canopy and habitat across much of the 350 km region (McHugh et al. 2018; Rogers-Bennett and Catton 2019; McPherson et al. 2021) resulting in devastating impacts on the ecological and human communities that depend on kelp. High densities of purple sea urchins remain across much of the region and continue to suppress kelp recovery in the region, though oceanographic conditions have since stabilized. A series of highly collaborative, science-driven restoration projects have been launched in the region since 2019 in order to create a network of bull kelp refugia to create habitat, preserve genetic diversity, and maintain spore sources to facilitate broader bull kelp recovery (Hohman et al. 2019). Here we will explore the specific tools -- from urchin traps to commercial hand harvest, to *in situ* culling by recreational divers, to green gravel -- and the scientific and collaborative approaches used in a suite of projects aimed at address kelp forest declines in the region.

Kelp Conservation and Recovery in Puget Sound and the Pacific Northwest

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Kelp restoration and conservation efforts in Puget Sound are gaining momentum. Bull kelp is the only canopy forming kelp species in Puget Sound. Fringing underwater forests – vital to human communities and the marine ecosystem – are a fraction of their former abundance in Central and Southern Puget Sound. Tribal Leaders are urging restoration and sharing knowledge of Kelp Lifeways that have supported communities since time immemorial. Puget Sound Restoration Fund (PSRF) has partnered with Tribes and agencies to build restoration capacity, growing a kelp forest from seafloor to sea surface three years running, 2020-2022. In response to declines, the National Oceanic and Atmospheric Administration partnered with Washington Department of Natural Resources and local organizations to develop the 2020 *Puget Sound Kelp Conservation and Recovery Plan*. To breathe life into the Plan, PSRF led an 8-day 2021 KELP expedition with 40 partners, and the Washington State Legislature provided funding for Plan implementation 2021-2023. Moving forward, a 3-year Eyes on Kelp Initiative funded by the Paul G. Allen Family Foundation has established 14 Kelp Index Sites throughout Puget Sound. Underwater ecological surveys paired with environmental monitoring of benthic and surface conditions will illuminate conditions driving persistence and decline. New monitoring technology at a pilot site will further inform management. As of 2023, "floating kelp canopy area" will be finalized as a Puget Sound Vital Sign indicator. Across the border, in British Columbia, a kelp node is likewise growing, with a coalition of partners focused on science, stressors, seed banking and surveys.

Abstracts

Lessons learned from the restoration of *Cystoseira* s.l. forests in the Mediterranean: challenges and wins.

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The field of marine habitat restoration has developed rapidly in recent years and is likely to accelerate with the UN Decade of Restoration (2021-2030). Despite a relatively long history in some countries, the science and practice of marine forest restoration in the Mediterranean is still in its infancy and there is much to learn from failures and successes. Furthermore, the field of macroalgal restoration lags behind other marine ecosystems, with fewer projects and smaller restoration efforts.

Recently, growing awareness and concern about the increasing threats and observed declines has led to several publications with recommendations for the restoration of *Cystoseira* s.l.

To some extent, biological, environmental and logistical challenges have been overcome and lessons learned can help in selecting the best sites, species and protocols for restoration. While climate change makes restoration urgent, it also limits its feasibility. Both natural and restored populations face the same threats (e.g., thermal anomalies, storm surges) and it may no longer be possible or advisable to restore the same species or population in an area where it previously occurred.

An important challenge is to address the often difficult goal of scaling the impact of restoration to the scale of forest loss. Effective scaling requires consideration of spatial and temporal variability in environmental factors (e.g., nutrients, temperature, local oceanography), stressors and connectivity, as well as consideration of cost-effectiveness, permitting constraints and logistical support needs to ensure the feasibility and success of restoration.

Abstracts

Marine forest reforestation project of Korea Fisheries Resources Agency (FIRA)

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The barren ground areas is extending and this phenomenon occurs as a result of several factors such as herbivore, over coastal development, and climate change (seawater temperature rising, ocean acidification). Korea Fisheries Resources Agency (FIRA) has established 2011 to protect coastal ecosystem in Korea. FIRA aims contributing to the national economy by establishing a foundation for sustainable use of fisheries resources especially in part of the marine forest project, the goal is greening 75% of the all coastal areas. FIRA has conducted marine forest enhancement that the areas of marine forest were over 292 km2 until

2022. For marine forest reforestation project, FIRA select appropriate site and use the artificial reef. FIRA use several methods for reforesting marine forest such as longline, spore bag, and catching the herbivore in the reforestation sites. In addition, FIRA investigated the development of technologies and strategic for climate change responses and future growth. We will try to set- up 540 km2 of marine forests to 2030 that marine forests could provide habitat for marine organisms and reduces greenhouse gases and so on.

Keywords: Barren ground, Korea Fisheries Resources Agency (FIRA), Marine forest reforestation project

Abstracts

Kelp cultivar development in China: history, techniques and achievements

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The big success of kelp farming in China is mostly attributed to the establishment of summer-seedling technique (hatchery), development of versatile cultivars (breeding) and efficient application of the so called long-line grow-out system (cultivation). Use of cultivars in *Saccharina japonica* has helped to increase the yield from 5-10 kg (fresh weight) per meter cultivation rope in the 1970s to the present 20-25 kg in 2022. Similar values have also been reached in *Undaria pinnatifida* amounting to ca. 20 kg m^{-1} at the end of harvesting season in northern farming region in China. Breeding is surely the most reliable pathway to increase the efficiency of kelp farming per hectare of open water. Genetic stability (inheritance) of agronomic characteristics in a cultivar determines its true value in production. For most of the kelp species, use of vegetatively propagated gametophytes for mating and seeding, would generate a sporophytic population with uniformed genotype when the parental gametophytes are genetically clear, free from other contaminations. Use of these gametophyte techniques (isolation, culture, mating choice, breeding scheme etc.) will surely become the main stream in guiding our future effort for generating cultivars with unique features. In this way, the goal of "unique cultivar for unique water" is expected to be realized in the near future.

Role of seaweeds in Alleviation Global Warming

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The temperature of our planet has increased by 1.2 ± 0.1°C, compared to its preindustrial values, three quarters of which takes place in the past 40 years. Anthropogenic emissions of greenhouse gases (GHGs) have been considered as a main trigger of current climate change. Lowering emission of GHGs and capturing GHGs are two major approaches to slow down the global warming trend. Human activities transfer carbon fixed in the fossil fuel to carbon oxide into the air. Hence, the carbon oxide could be reduced by refixing into biomass. Marine algae transform nearly 50 Gt of carbon dioxide each year from the atmosphere and convert it into biomass. The seaweed ecosystem acts as a carbon sink, and carbon retained by seaweeds could be buried in sediments or migrate to the deep sea. Furthermore, since carbohydrates present 30 - 80% of the overall carbon content in algal biomass as storage of carbon and energy, seaweeds can be used as a carbon buffer to lower carbon dioxide in the atmosphere. The total global seaweed production (wet weight) are approximately 36 million ton annually, in which 97.38% from Asia and 97.0% are farmed seaweeds. China is the largest seaweed producer, and produced 56.75% of the overall seaweeds worldwide and 58.02% of farmed seaweeds. These farmed seaweeds can be consumed as foods and used for industrial purposes, which will prolong carbon in solids and supress the rate of atmospheric carbon dioxide increase. The length of the Australian coastline is similar to that of the Chinese coastline. Australia's pristine and isolated coastal environment provides a massive opportunity for seaweed farming. Assuming the productivity of Australia increases to 10% of the productivity of China, 0.2 million ton (wet weight) seaweeds will harvest 0.22 million ton of carbon dioxide annually, based on equivalent 10% dry weight and 30% carbon content. Based on prices of carbon credits, \$37/ton CO_2 in Australia, an additional \$8 million could be added to industry annually.

Novel Algal Extracellular Polymeric Substances (EPS)-based Hydrogels for the Efficient Removal and Recovery of Phosphorus from Contaminated Waters: Development, Characterisation, and Performance

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Adsorption is assumed as an effective and reliable method to recover phosphorus (P) from sewages. Extracellular polymeric substances (EPS) and agarose are common polysaccharides bio-resources. Their carboxylic and phenolic hydroxyl groups directly adsorbed P by ion exchange and hydrogen bonds. Here, we designed EPS-based and Fe-modified hydrogels (agarose (AG) and agarose-humic (AH) based hydrogels) for P recovery. The effects of coexisting anions (i.e., SO_4^{2-}, NO_3^-, and CO_3^{2-}) and pH (pH=3-10) on adsorption were tested. AG and AH hydrogels adsorbed 33.9 and 67.7 mg P g^{-1}, respectively. Both as-developed hydrogels showed >75% of the maximal adsorption capacity in the tested pH conditions. Coexisting anions did not significantly affect the adsorption performance, except for CO_3^{2-} which inhibited the process. Intra-particle diffusion controlled the adsorption process. After adsorption, large amounts of $FePO_4$ and $Fe_2(HPO_4)_3$ were generated in the hydrogels, confirming that ligand exchange was the major driving force. Overall, the developed EPS-based hydrogels can be used to remove and recover P from water efficiently.

Effects of Perfluorooctanoic Acid on *Microcystis aeruginosa*: Stress and self-adaptation mechanisms

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The persistent organic pollutant perfluorooctanoic acid (PFOA) is ubiquitous in the aquatic environment. However, little is known about its toxicity to cyanobacteria or the mechanisms by which they self-adapt to it. This study revealed that the bloom-forming cyanobacterium *Microcystis aeruginosa* was initially inhibited and subsequently self-adapted to PFOA exposure for 12 d. PFOA inhibited *M. aeruginosa* growth but the inhibition rate gradually decreased and stabilized over time. With increasing PFOA concentration, the reactive oxygen species levels and superoxide dismutase and photosystem II activity significantly increased while the respiratory rate, NDH-1 activity, and total carbohydrate content significantly decreased. Self-adaptation mechanisms included the antioxidant pathways, energy transfer and distribution of photosystems, and repair of the PSI and NDH complexes. The patterns of change in the foregoing parameters were consistent with those of the expression levels of the genes in their associated metabolic pathways. In addition, PSII overcompensation might be a strategy by which *M. aeruginosa* contends with oxidative stress induced by PFOA. Various downstream photosynthesis-related proteins were upregulated in response to increasing PFOA exposure time. These findings may help elucidate the physiological and genetic stress and self-adaptation responses of microalgae to PFOA exposure.

Abstracts

Spatiotemporal dynamics of marine microbial communities following a *Phaeocystis* bloom: biogeography and co-occurrence patterns

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Marine microbes play important roles in the development of phytoplankton blooms. The diversity and composition of free living (FL) and particle attached (PA) microbial communities have been well studied, while little is known about their geographic and cooccurrence patterns, especially during the subsiding process of *Phaeocystis globosa* blooms. Herein, the beta-diversity of FL and PA microbial communities in both the surface and bottom layers of different habitats were comprehensively examined during succession of a *P. globosa* bloom event. The results showed that microbial communities from bloom and nonbloom sites exhibited distinct community compositions. Among the different sampling sites, the community similarities decreased with spatial distance, in which the FL communities' similarity in bottom waters was more influenced by spatial variation. The variation of microbial communities was mostly attributed to environmental selection, spatial distance, and the abundance of *P. globosa* successively. The cooccurrence networks of microbial communities in bloom and non-bloom waters differed in terms of structure and composition, and the bloom network had more links and closer relationships between genera than the non-bloom network. The correlation among genera and modules suggested that the bloom microbes were likely driven by high environmental selection and low competitive effect between each other.

Technical and economic assessment of algae-based desalination

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Desalination processes are critical for producing freshwater from salty water, and an algae-based desalination approach has drawn increasing attention as a potential low-cost and passive-energy desalination technology, which could be a competitive solution to desalination in remote areas impacted by water shortages. We have studied the algae-based desalination from technical and economic perspectives. Our study demonstrated that both adsorption and absorption contributed to the salt removal, but adsorption played a more significant role (two thirds of the salt removal). The full adsorption can be reached within a relatively short period (1–30 min), and the salts removed by absorption is negligible when the contact time was short. Comparing with the high pressure reverse osmosis desalination and microalgae based desalination systems, the hybrid desalination system based on the combination of low pressure reverse osmosis and microalgae is considered as the most economical and environmentally friendly option.

Abstracts

Fucus species for methane reduction in dairy cattle

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In previous *in vitro* experiments simulating rumen fermentation, it has been found that two *Fucus* species. possess significant ability to suppress methane formation associated with rumen fermentation of feeds. In contrast to *Asparagopsis* species the anti-methanogenic activity of *Fucus* species cannot be ascribed to halomethanes. The aim of this experiment is to investigate, whether the anti-methanogenic properties of the *Fucus spp.* can also be obtained *in vivo*, considering the dynamic flow-through system in the forestomachs of ruminant animals. Three multi-cannulated (rumen, duodenum and ileum) Danish Holstein dairy cows are used in a 3 x 3 Latin square design experiment, with three periods of three weeks duration, where cows are fed three different total mixed ration (TMR): a control TMR without seaweed and two rations where the control TMR has been diluted on dry matter basis with 4% of either of the two *Fucus* species. The effects of adding seaweed to the rations are assessed for feed intake, feed digestibility, milk production, and methane emission. The first 14 days of each period is assigned to adaptation to the diet, followed by three days of digesta sampling and subsequently four days of gas exchange measurements in respiration chambers. Data will be available for presentation at the symposium.

Abstracts

Enteric methane emission from dairy cows fed three brown seaweed species

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Methane is formed as a by-product during fermentation of feed primarily in the forestomachs of ruminants. However, methane is a potent greenhouse gas, and thus of concern in relation to climate change. Seaweeds procured from the Northern hemisphere have shown potential to reduce *in vitro* methane production. This study aimed to investigate the *in vivo* effects of three brown seaweeds (Phaeophyceae) on enteric methane emission and feed intake of dairy cows. The experiment was conducted as a 4 × 4 Latin square design using four lactating rumen, duodenal, and ileal cannulated Danish Holstein dairy cows. Seaweed products were dried and ground prior to mixing into the experimental rations. The cows were fed a ration without any seaweed or the same ration diluted with, on a dry matter-basis, either 4% ensiled *Saccharina latissima,* 4% *Ascophyllum nodosum,* or 2% *Sargassum muticum*, for periods of 21 days. Methane emission was measured during the last 4 days of each period using respiration chambers. Additionally, dry matter intake (DMI) and milk yield were recorded. Milk yield and DMI were unaffected by the dietary inclusion of seaweeds (P-value 0.51 and 0.34, respectively). Moreover, none of the three seaweeds, added to rations, affected methane emission expressed as g/d or as g/kg DMI (P-value 0.14 and 0.84, respectively). In conclusion, the inclusion of dried and ground *A. nodosum*, *S. muticum,* or ensiled *S. latissima* in the feed ration of dairy cows had no impact on neither cow productivity nor methane emission.

Effects of feeding European seaweeds on performance, gas production and rumen microbiota in dairy cattle

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Research on supplementing ruminant diets with seaweeds has mainly focused on the use of *Ascophyllum nodosum* (Phaeophyta) and *Asparagopsis taxiformis* (Rhodophyta). In the current study, supplementation of diets of lactating dairy cows with three algae commonly found in northwestern Europe was evaluated for its effects on lactational performance, enteric gas production and rumen microbiota composition. 64 Dairy cows (91 ± 22.6 days in milk; 35.4 ± 8.13 kg/day fat- and protein-corrected milk; mean ± standard deviation) were randomly assigned to one of four treatments. A basal diet (54% grass silage, 21% corn silage, 25% concentrate; DM basis) was not supplemented (control) or supplemented with either 150 g/day (fresh weight of dried seaweed) of *Chondrus crispus* (Rhodophyta), *Saccharina latissima* (Phaeophyta) or a 50/50 mixture (DM basis) of *S. latissima* and *Fucus serratus* (Phaeophyta). To investigate short- and long-term effects of seaweed on the rumen microbiota, 8 cows per treatment were randomly selected and rumen fluid (performed 16S rRNA amplicon sequencing) was obtained via oral stomach tube technique at five different time points (-3, 2, 35, 60 and 81 d after first day of feeding seaweed). Milk yield (29.5 vs 28.3 kg/d, respectively) and milk lactose content (4.59 vs 4.53%, respectively) increased at *S. latissima* compared to the control. Other milk or efficiency related parameters did not differ between the control and the seaweed treatments. Gas emissions (CH_4, CO_2 and H_2) were not affected by the seaweed treatments. Microbiota composition results are currently being evaluated and will be presented at the congress

Abstracts

Carbohydrate composition of 22 macroalgae species and their potential as future feeds for ruminants

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Macroalgae have attracted significant attention in recent years as potential feeds or feed additives, since their cultivation is not associated with use of arable land suitable for human food production, and because of the ability of some species to reduce methane formation during enteric fermentation in ruminants. However, most macroalgae species have a low digestibility, even for ruminants, due to the unique and complex carbohydrate (CHO) structure in cell membranes. This represents an obstacle to be overcome in order to implement macroalgae as future feeds in livestock diets. There is only limited information available on rumen degradability of the individual CHOs, including simple sugars, oligosaccharides and non-starch polysaccharides (NSP). It is the aim of this project to establish, how individual CHOs in seaweed are degraded in the rumen to be able to develop methods to increase their digestibility. In this experiment, presently in progress, we use 22 macroalgae species (brown, red and green species) for *in vitro* experiments simulating rumen fermentation. CHO composition of the intact macroalgae and the undigested remains after fermentation in rumen inoculum are analysed for contents of NSP as monomeric sugars, simple sugars and oligosaccharides. Gas production during the simulated rumen fermentation, and pH and volatile fatty acid (VFA) produced during the fermented are also measured in the fermented fluid after 48 hours of *in vitro* fermentation. Data will be available for presentation at the symposium.

Abstracts

Australian brown seaweeds as a source of essential dietary minerals

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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 rich sources of dietary trace minerals and essential elements that are often not found in terrestrial edible plant foods. However, due to the high affinity for mineral and contaminant accumulation by seaweeds, it is important to conduct in depth studies on Australian seaweeds that have edible potential and are being considered for sustainable aquaculture or wild harvest. This study screened 6 Australian fucoid and laminarian brown seaweeds for the presence of 70 elements, of which 50 were quantified. Replicate samples of each species were collected from 3 'clean' Victorian sites (classified based on their remoteness to urbanisation and potential pollution sources) and processed consistent with methods for human consumption. Dried and ground samples were analysed by ICP-MS and concentrations of 15 key dietary minerals were compared amongst species and locations. Results will be discussed in the context of the potential health benefits from consuming the species studied in realistic quantities

The lettuce of the sea: a 10-year history from an EU farmer

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Exactly 10 years ago, in 2013, ALGAplus Ltd., sold its first kilos of farmed sea-lettuce as a food product. This seaweed has since been farmed in a land-based “finfish + seaweed” integrated (IMTA) system set in Ria de Aveiro, Portugal.

From the initial founding team of 4 biologists, 2 members linger and have now been joined by 20 more skilled persons. As for the seaweed, from 12 species, the focus is now on a set of 4, with the foliose *Ulva* sp. at the forefront.

The company has developed and validated cultivation and biomass stabilization protocols, while fostering market acceptance for its targeted “cash-cow”, the food product sea-lettuce (identified as *U. rigida* C. Agardh and *U. laetevirens* Areschoug). This has been done by settling its industrial development on research, assured by a strong investment in training, local and worldwide partnerships, and project participations; the presentation will cover the main outcomes of this strategy.

An overview of the past 10 years will include data on production, product development, marketing strategy, consumer acceptance and market growth for EU farmed *Ulva* sp. Food as the core sector, but with key results on feed, cosmetics and biomaterials applications of the biomass, or its fractions, also presented.

From the initial 500L tanks in 2012, to the current 300m^2 raceway units, in 2023 the company targets at least 110 tonnes (fw) of organic certified farmed sea-lettuce biomass to be sold as food. Not much for Asian production levels, but a crucial milestone for an EU young seaweed farmer and to the democratization of sourced seaweed consumption in western countries.

Abstracts

Large-scale sea-based aquaculture of *Ulva*

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Compared to Asia, seaweed aquaculture is in its infancy in Western Europe. However, due to the multi-applicable usage of this renewable resource there is a rapidly growing interest in efficient production technologies to foster a large-scale industrial production of seaweed biomass. Especially the sustainable oceanic cultivation of seaweeds is attractive as it does not compete with terrestrial crops for space and freshwater, and as extractive organisms seaweeds do not afford fertilization whilst providing high biomass yields.

This study monitored the effect of seasonality on the overall biomass performance (growth, biomass yield), chemical composition (fatty acid, protein, carbohydrate, pigment, phenolic, biochar, ash, and element composition), fertility (total amount of fertile thallus tissue), and biofouling (total coverage) of Swedish off-shore cultivated *Ulva fenestrata*, in order to find suitable harvest times for biorefinery purposes. Specimens of *U. fenestrata* were cultivated in an off-shore seafarm in the Kosterfjord, Sweden from October to five different harvesting points in April, May and June. Statistical analyses confirmed that there was a significant

difference in overall biomass performance and biochemical composition among the time points. Our study confirmed the large scale off-shore cultivation potential of northern hemisphere *U. fenestrata* and underpins suitable harvest time points to facilitate industrial valorization processes of the off-shore cultivated biomass. Together, these results indicate that seasonality and the selection of harvest periods are crucial factors to consider in order to facilitate high yields, respective quality as well as desired biochemical traits in future oceanic *Ulva* farms.

Abstracts

A rapid methodology for the selection of *Ulva* elite strains tailored to specific growth conditions

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Sea lettuce (*Ulva* spp.) is recognised for its potential in food, pharmaceutical, nutraceutical, biorefinery and bioremediation industries and is increasingly being cultivated in aquaculture. The demands of industrial applications vary widely in terms of biomass composition and cultivation requirements. To screen a large diversity of wild-isolates, we tested the suitability of garden experiments, i.e. co-cultivation of many strains under specific growth conditions. We have characterised species composition over time among foliose strains cultivated in seawater and brackish waters, the latter being suited for bioremediation of land-based wastewaters. Our findings reflect the competitive advantage of strains displaying fastest growth in both environments. Interestingly, growth rates after a month were very similar, suggesting that selected strains cope equally well in either media. Further, we found significant variation in the composition of biomass produced in both conditions, in particular protein and carbohydrate content. We have now applied this protocol to the identification of filamentous *Ulva* strains with improved tolerance to long-term low salinity and are establishing similar trials for selecting locally-sourced strains adapted to aquaculture and industrial waste-water treatment. The established bulk-selection protocol provides a distinct advantage in efficiently screening large numbers of strains for their suitability to a target application

Abstracts

Climate positive value chains from gentle harvest and processing of sea lettuce – mission possible?

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To utilize non-animal protein sources for human consumption, extraction of the protein is sometimes needed to reduce a high content of fibres and phenolic compounds, interfering with protein digestibility. Another aspect may be the need for upcycling of wild harvested biomass. In a science-industrial Danish case-study we explore water quality improvement obtained via gently harvest of excess nutrients assimilated in green tide seaweed *Ulva* spp. The innovative harvesting technology and processing into two different *Ulva* protein concentrates are tested. Preliminary result of the assessment of the environmental sustainability, nutritional value, and economic viability of processing the harvested *Ulva* into final protein ingredients as a meat replacement in combination with legume protein is presented.

Ulva is characterised as a high productivity protein source with a high content of essential amino acids (36–42% of total amino acids). This study presents a comparative life cycle assessment (LCA) of gently harvest and processing of *Ulva.* Environmental performance of the whole value chain, from harvest to processing into final products, is assessed. Furthermore, LCA results are presented using nutritional measures as the functional unit, which enables an integrated assessment of environmental and human health aspects of the alternative food products, while net present value approach is applied to address the economic viability of future pathways towards a more plant-based diet.

Abstracts

Harvest of sea lettuce as a tool for habitat restauration supporting the blue bioeconomy

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Sea lettuce (*Ulva* spp.) forms massive green tides in nutrient-rich water bodies around the globe. The decomposing of *Ulva* biomass reduces environmental quality and recreative value. Harvest of *Ulva* prior to decomposition is of increasing interest as a tool to improve environmental quality and contribute to the circular bioeconomy.

In a science-industrial Danish case-study, the extent of *Ulva* green tides was documented between 2018 and 2022 using drone and image technologies. Gentle mechanised harvest of the *Ulva* biomass was tested and documented over three seasons, registering environmental impacts and *Ulva* biomass quality for food and feed purposes. The biomass abundancy peaked in late summer with biomass densities up to 58 tonnes of wet weight per ha. Harvest was challenged by the *Ulva* gathering at shallow depths, and by limited options for selective harvest targeting optimal biomass quality. The potential for removal and re-use of nutrients was estimated to 110 kg of nitrogen and 30 kg of phosphorus per ha. The harvested biomass contained up to 14% of epi-fauna animals of relatively low biodiversity, indicating a 'moderate' ecological status (Shannon index between 1.04 and 1.71). The cost of harvest was estimated to 540 US$/ton *Ulva* dry matter (DM). The biomass crude protein content ranged between 6 and 20% of DM, concentrating up to 5-fold by post-harvest processing.

Harvest of *Ulva* can be used as a tool to improve environmental quality in nutrient-rich water bodies, however improving harvest method and post-harvest processing is needed for utilising the biomass for food and feed.

Abstracts

Rainbow seaweeds: exploring the physiology of structural colour in species of *Chondria* (Ceramiales, Rhodophyta)

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Seaweeds are colourful organisms, and pigmentation is not the sole mechanism behind the colours of some species: structural colour occurs due to nano-structures causing refraction and interference in the incident light and reflecting particular wavelengths. It results in intense, sharp and often iridescent shades where the tissue appears to shift colours with the angle of view. In red algae, two known types of mechanisms create structural colour: multi-layers and iridescent bodies. In this study, we focus on two species of the red algal genus *Chondria* (Rhodomelaceae) where structural colour is due to intra-cellular iridescent bodies. In Britain, *Chondria coerulescens* is a summer annual species growing on very sheltered, silty shores. Structural colour gives it strikingly turquoise to purple hues throughout the branches. *Chondria scintillans* is found on slightly more exposed rocky shores all year around and more significantly in late winter. Its structural colour is less conspicuous and shows as light turquoise spots on the branches. Both species grow on the lower shore and shallow subtidal waters along the Atlantic coast of Europe. *Chondria scintillans* appears to be expanding its range northwards and has only recently been reported for the first time for Britain from the South Devon. We hypothesise that structural colour provides a protective mechanism against damaging light while also enhancing photosynthetic efficiency under low light conditions. Using PAM fluorometry, we raise questions on the impact of the iridescent bodies on the photosynthetic activity, seasonal variations, and possible differences in the photophysiology of these two closely related species.

Abstracts

Structural colour in the seaweeds: a phenomenon for our time?

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The earth is a remarkable place and seaweeds have occupied it for over a third of its existence. Massive upheavals and dramatic changes in climate over the evolutionary history of these remarkable organisms have shaped the seaweeds we see today. Structural colour in seaweeds is a widespread product of that history and we hypothesise that the range of structures evolved are innovations that have enabled species to adapt and survive. We see the physical effect of these structures as striking blue through turquoise to green and pink iridescence. A once neglected subject, our work is demonstrating that this phenomenon is much more widespread than previously reported both geographically and phylogenetically. For example, in the brown algae, structural colour had only been reported in the Dictyotales (oldest group) and Fucales (most recent group), but our recent South Atlantic work has shown that it also occurs in the Desmarestiales and Laminariales. There may be more structures than previously thought or variation in their arrangements, such as in the green algae where microfibrils vary in orientation in different species. We also seem to be seeing more iridescence in the field than in the past. This may reflect greater awareness or range expansion of species with structural colour into new geographical areas but it also raises questions as to whether structures can be mobilised, created or acquired in response to climate change. This talk will explore these ideas through new observations and geological and contemporary hypotheses.

From the bottom up: impacts of climate change on seaweed nutritional properties and marine food webs

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Extreme events such as marine heatwaves have had major impacts on temperate ecosystems and are becoming more intense and frequent. Seaweeds are foundational components of temperate coasts providing nutrition and habitat that underpin a diverse ecosystem. Rich in nutrients such as essential fatty acids, antioxidants, and vitamins, seaweeds support temperate ecosystems from the bottom up. However, it remains poorly understood whether climate-driven environmental change will impact nutrients in seaweeds and their availability to consumers. Using novel lipid- and metabolomics techniques we test the effects of warming and marine heatwaves nutritional quality of two foundational Australian seaweeds; *Ecklonia* and *Sargassum*. We then model changes in nutrient availability in response to climate-driven ocean warming throughout each species' eastern Australian distribution. The consequences of reduced seaweed nutritional quality (e.g. lower levels of essential fatty acids) are likely to reverberate throughout marine food webs, with implications for consumers and the transfer of energy within marine food webs. Understanding how the nutritional quality of primary producers such as seaweeds will be affected by climate change is vital to anticipate and manage climate-driven changes in temperate ecosystems.

Abstracts

Ocean acidification increases porosity and reduces tissue strength in a non-calcifying foundation seaweed

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Climate change due to anthropogenic activities has already resulted in unprecedented global changes, in part due to ocean acidification which can have powerful effects in the nearshore, shallow areas of the oceans where seaweeds are foundation species. Here we conducted experiments to investigate the effects of ocean acidification on the habitat-forming seaweed *Fucus vesiculosus*. We assessed effects on growth, thallus breaking strength, and drag, under both lab and field conditions. Additionally, we quantified the calcium and magnesium content of some seaweed tissues and compared this to scanning electron microscopy (SEM) imagery of thallus tissue to examine possible effects. Tissue resilience decreased when seaweeds were exposed to increased pCO_2, corresponding with an increasing risk factor. This suggests that this species is more likely to suffer damage by mechanical stress such as grazing or wave action; we observed greater loss of these individuals in a field transplant experiment. Tissue exposed to increased pCO_2 contained less calcium and magnesium, both of which are important the creation of structural alginate matrices. When these samples were viewed under SEM, there were voids forming in the tissue matrix of seaweeds grown under elevated pCO_2 that were not present in control seaweeds. Reduced tissue resilience implies that climate change may lead to a future decline in populations of habitat-forming seaweeds, which may have large negative consequences on associated organisms that depend on this habitat-forming species. These effects could either be localized to specific populations or widespread, especially when combined with predicted increases to storm frequency and power.

Impacts of ocean warming and acidification combined, on physiological and biochemical composition of *Ulva sp*.

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Ulva is a cosmopolitan macroalga, playing an important role as a food source in marine ecosystems. However, the effects of future climate change scenarios in this genus is unclear. Ocean warm-up and pCO2 increase could lead to unpredictable consequences regarding seaweed ecophysiology, ecological services, and consequently marine food chains. In the present study, we will assess morphological, physiological, and biochemical responses from *Ulva sp*. cultured in 4 different controlled conditions analogous to the expect variations in pH and salinity in tropical waters: control (pH 8.1 and 24°C), acidified (pH 7.7 and 24°C), warmed (pH 8.1 and 43.7°C) and acidified and warmed (pH 7.7 and 43.7°C) during 2weeks. During these weeks we will access algae productivity, photosynthetic apparatus, the content of fatty acids and other metabolites, C/N ratios, mineral content and, polysaccharide yield.We expect to find significant variations in the content and diversity of the metabolites, as well as to evaluate the impact of heating and acidification on the nutritional quality of *Ulva sp*.

Functional response of macroalgal communities as a tool for monitoring nutrient enrichment

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As coastal urbanisation and industry intensify, nutrient enrichment from human activity has been identified as a key local impact on the function of macroalgal communities in inshore reef ecosystems. As macroalgae communities are often fundamental for the delivery of ecosystem services, understanding the local-scale sensitivity or resilience of these systems is critical. In south-east Tasmania, open cage finfish aquaculture is well established, however, to be sustainable it must operate without adversely impacting ecosystem services. Developing monitoring methods which are sensitive to a loss of resilience, yet simple and cost-effective enough to be used in ongoing monitoring is a challenge. In this study we designed and tested a method based on a suite of relatively easy-to-observe functional parameters and nutrient enrichment indicators in macroalgae communities. Parameters were designed to characterise ecosystem structure (canopy, brown/green/red algae understorey, substrate), along with typical responses to nutrient enrichment, such as the cover of epiphytic, filamentous and nuisance algae. The method was tested through diver-based surveys across a localised enrichment gradient. While it was successful in detecting a farm gradient of enrichment, the confounding influence of wave exposure made interpretation of data difficult. Multiple lines of evidence and robust baseline data are key to resolving effects, particularly in the diffuse enrichment zone. While this technique shows promise for detecting impacts of enrichment from human activity on reef communities, it also highlights the susceptibility of algae communities in low wave exposure sites to impacts of enrichment, regardless of the source of nutrients.

Abstracts

Genomic and multilocus analyses of Palmariaceae (Rhodophyta) from Southern Hemisphere confirm new additions in *Devaleraea*

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In the northern hemisphere, more than 18 species of Palmariaceae have been confirmed molecularly. In contrast, only three species – *P. decipiens, P. georgica,* and *D. yagan* – have been identified in the southern hemisphere. The former is a dominant marine red algal species that provides habitat, nourishment and shelter for many marine organisms along Antarctic and Subantarctic Island ecosystems; the second is a small gregarious plant reported from South Georgia, Heard and Macquarie Islands; and the latter one is a tiny species restricted to the Beagle Chanel, Magellan region. A new assessment using multilocus (i.e., *cox*1, *rbc*L, nuclear-encoded ITS rDNA) and genomic sequencing of fresh material of Palmariaceae from topotype localities revealed the following new combinations in the genus *Devaleraea*, namely *D. antarctica* comb. nov. which is sister to *D. mollis*; and *D. decipiens* comb. nov. which is sister to a cluster of *Devaleraea* species. The new assembled genomes of *D. decipiens* showed high gene synteny with *D. antarctica* and *P. palmata,* however minor differences are documented. Organellar genome content and phylogenetic analyses of *D. decipiens* supports its placement in the Palmariaceae.

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Abstracts

An endemic epiphytic New Zealand red seaweed, *Pyrophyllon subtumens*, contains novel disaccharide repeat units

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Polysaccharide structure is related to taxonomy in many red seaweeds. An endemic epiphytic New Zealand red seaweed known for many years as *Porphyra subtumens* (J.Agardh ex Laing) was re-classified in 2003 from the order Bangiales into an entirely new genus in the order Erythropeltidales based on molecular sequencing data as well as on the high level of xylose it contains. This species is now called *Pyrophyllon subtumens* (J. Agardh ex Laing) W.A.Nelson but no detailed characterisation of its hot-water soluble polysaccharide has been undertaken.

Chemical and spectroscopic methods were used to determine the type and linkage/substitution of individual sugar units within the polysaccharide, and a partial sequencing protocol was used to identify certain disaccharide units. Results of these analyses will be presented.

This is the first detailed characterisation of a polysaccharide in the Compsopogonophyceae class of the Proteorhodophytina subphylum, and the unusual polysaccharide found in *Pyrophyllon subtumens* supports its earlier reclassification from *Porphyra subtumens*.

Nuclei isolation to evaluate genome size of the red alga *Gracilaria caudata* using flow cytometry

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Flow cytometry (FCM) is widely used to estimate genome size in terrestrial plants. However, there are few studies in seaweeds due to difficulties such as nucleus release due to the cell wall polysaccharides and selection of a standard reference species genomically similar to the evaluated sample. In this work, an FCM analysis of *Gracilaria caudata* gametophyte was made by adapting a methodology used for land plants for nuclei isolation to confirm an estimate of the genome size. Twenty milligrams of species were used for each replicated (n = 3). The nuclear isolation protocol followed Galbraith et al. (1983) in a sample immersed in buffer described by Otto (1992) with modifications. In addition, propidium Iodide diluted in the Otto II buffer was used along with RNase to stain the nuclei. Before FCM, samples were analyzed under fluorescence microscopy to ensure nuclei isolation. *Kappaphycus alvarezii* tetrasporophyte was used as a standard internal reference to calculate the C value further. Fluorescence microscopy showed disaggregated and viable nuclei. The average value of the *G. caudata* genome size was estimated at 1C = 0.23 pg, approaching the value found by Lopez-Bautista and Kapraun (1995) of 0.24 pg, using the microspectrophotometry technique. In conclusion, establishing one fast and viable FCM protocol for *G. caudata* opens possibilities for future studies related to strain selection, manipulation of ploidy, and seaweed species' genetic understanding.

Abstracts

Genomic analysis provides insights into the evolution of *Ahnfeltia* (Florideophyceae, Rhodophyta) and its divergence

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Genomic divergence and genetic differentiation of many seaweeds are associated with spatial distribution in the ocean and geographic isolation. *Ahnfeltia* is a red algal genus forming tangled tufts with thin branches. It is known for high quality agar production with a low sulfate ratio. Three *Ahnfeltia* species are distributed in different areas: *A. plicata* is found in the North Atlantic, Chile and Tasmania, *A. fastigiata* is in the North Pacific, and *A. borealis* is only in the North American Arctic. We postulate that *Ahnfeltia* species have diverged along with past climate change and somewhat strict geographic isolations by warm ocean currents and the equator because *Ahnfeltia* growth is favorable to cold-water condition. To investigate the evolutionary history of *Ahnfeltia*, we *de novo* assembled nuclear genomes of three *Ahnfeltia* species and conducted whole genome re-sequencing of 78 individuals from eight populations. Principal components analysis (PCA) and population admixture indicated that *Ahnfeltia* populations have been isolated without any evidence of gene flow among populations after dispersal. A high fixation index (Fst) among species and population indicated high genetic divergences of *Ahnfeltia* populations. However, assembled pseudo-chromosomal genomes revealed that core gene inventories were conserved. Genome expansion between *A. plicata* and *A. fastigiata* occurred mainly due to transposable elements (TEs). TEs also likely involved in the genomic recombination in *A. plicata* Chile population. Thus, it is suggested that TEs played an important role in genomic divergence during the speciation and divergence of *Ahnfeltia*.

Abstracts

Geographic barriers for red seaweed in the Northwest Pacific: the case of *Dichotomaria elegans*

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To understand speciation mechanisms in red seaweed, it is important to recognize cryptic species and assess their dispersal ability. Due to high morphological similarity, some species are only distinguishable via molecular analysis and/or microscopy. Dispersal ability in red algae is considered limited by the absence of flagella, yet dispersal barriers in marine environments are difficult to establish.

Here we present a case of possible incipient speciation within the red alga *Dichotomaria elegans* (Galaxauraceae, Rhodophyta), found in the Northwest Pacific. Three sequenced loci (plastid *rbc*L, mitochondrial *cox1* and *cox2-3*) showed complete separation of two morphologically indistinguishable lineages. The two lineages are completely allopatric: lineage 1 is found in the northern Philippines and the southern/southwest coast of Taiwan, while lineage 2 has a wider latitudinal range, from the South China Sea, the eastern/northeast coast of Taiwan, to its highest latitude in Japan.

The split between the two lineages is dated approximately 1.5 – 3 Mya, suggesting their separation is due to geographic barriers raised during the Pleistocene. Molecular analysis showed that lineage 2 has a higher haplotype diversity than lineage 1. Ecological niche modeling showed that lineage 2 can tolerate a wider range of temperature, dissolved oxygen and phosphate, and lower salinity compared to lineage 1.

We hypothesize that lineage 2 has better adaptability to different water conditions, and its dispersal through the Kuroshio current led to its wider geographical range. We discuss implications on dispersal ability and allopatric divergence in marine red algae, both potential drivers of speciation within *D. elegans*.

Abstracts

Multilocus sequencing of *Carlskottsbergia* and "*Synarthrophyton patena*" from Southern hemisphere reveals a new Antarctic lineage

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The crustose coralline algae *Carlskottsbergia antarctica* was proposed to encompass *Melobesia verrucata* var. *antarctica* and other specimens subsumed in the broad concept of *Synarthrophyton patena* from southern hemisphere (i.e. southern Chile, southern Argentina, the Falklands, and Aucklands). However, the taxonomy of the monotypic *Carlskottsbergia* has been based solely on morphological features, while the circumscription of *S. patena* have not been properly assessed in the southern hemisphere yet. Here, we studied the genus *Carlskottsbergia* from southern Chile, including topotype material from Cape Horn, and specimens traditionally identified as *S. patena* from Antarctica using anatomical observations and multilocus data (COI, *psb*A and *rbc*L). Our results indicate that *C. antarctica* is a species complex of multiple evolving populations. Additionality, we recognized a new lineage from Antarctic peninsula sister to *C. antarctica* complex containing specimens previously identified as *S. patena*. Our analysis strongly supported it as a distinct genus by the multilocus phylogeny and anatomical observations. This new lineage differed from *C. antarctica* complex by 13.1-16.7% (COI), 4.2- 6.1 % (*psb*A), and 7.1-8.9 % (*rbc*L), whereas COI, *psb*A, and *rbc*L divergences from *S. patena* were 12.3-13.1%, 6.9-7.1 %, and 9.8-10.3 %, respectively. Morphologically, this candidate to new genus differed from *Carlskottsbergia* and *Synarthrophyton* in the chamber size of male conceptacle, the roof thickness, and the canal diameter in the apex.

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Seaweed Farming in Maine: A decade of development and innovation leading U.S. seaweed production

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Within the past decade Maine has emerged as the leader in U.S. seaweed production, with a growing number of commercial farms and processors, significant developments in supply chain and markets, and increases in landings, investments, and infrastructure. The U.S. is actively pursuing seaweed cultivation at a variety of scales for sustainable food and biomass production as well as co-benefits to cultivation, including carbon capture and sequestration in coastal waters. Furthermore, marine resource infrastructure and markets in Maine and the U.S. are well positioned to incorporate and expand seaweed crops and value-added products into revenue streams alongside traditional fisheries. In 2010, the U.S. had a single Maine-based kelp farm and undeveloped supply chain. Over a decade later, Maine has over 35 commercial kelp farms and has seen exponential growth in farm acreage and landings, diverse and expanding processing operations, and the creation of a viable supply chain. The rapid growth in Maine's emerging seaweed sector has been enabled by an organized permitting process, state and federal investments in research and development, a well-established maritime workforce and infrastructure, and coupled processor-product producer businesses that contract directly with seaweed farmers and work with wholesalers and retailers to reach end consumers. Continued investments in production and harvest systems, processing infrastructure and technology, new markets, and climate initiatives are critical to advancing the emerging seaweed sector in Maine and the U.S.

Lessons Learned Growing Macrocystis *Pyrifera* in the Southern California Bight

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Ocean Rainforest is an established international seaweed cultivation company that has successfully cultivated *Macrocystis pyrifera* for the first time in the Southern California Bight off the coast of Santa Barbara. Our first year of growth experiments began early in March of 2022 and have continued through to the first half of 2024. There have been many challenges to establishing consistent growth yield and by extension documenting growth curves. Some of those challenges center around the timing of outplanting, as well as maintaining healthy stock. These challenges have led to a better understanding of how to successfully cultivate Giant kelp in this region. We have and continue to focus on numerous experiments that lead to better understanding of yield drivers which also lead more efficient cultivation methods.

Additionally, our cultivation facility has participated in numerous partnered experiment that work towards better engineering designs centered around understanding kelp drag and infrastructure loads. Furthermore, we have participated in the establishment of better growth models as well as the development of technical tools that will better aid in the monitoring or observation of growth development. These observational tools include the use of side scan sonar for remote or hands-free infrastructure and biomass monitoring.

Abstracts

Evaluation of environmental performance of Chinese kelp cultivation on industrial scale gives new insights

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The environmental performance of cultivated seaweed has gained large interest. The low material, energy and water requirements together with nutrient uptake suggests seaweed can be a promising alternative source of food, fuel and biomaterials to mitigate environmental impacts. So far, the evaluations of environmental performance of seaweed are mostly based on European cultivations at research and pilot scale. This although Asia stands for 97 % of global seaweed production with China alone producing 58 %. In this study, we calculate and compare the environmental footprint of nine kelp production systems described in literature and include a Chinese farm at industrial scale that has not previously been described. We extracted inventory data from all studies and recalculated environmental impacts using Life Cycle Assessment (LCA), applying the same background data and method choices with the aim to compare effects of scale and cultivation system. The yearly harvest of the Chinese farm was 1000-4000 times larger than the farms previously evaluated with LCA. Preliminary results suggest that streamlined and mature production in the large-scale Chinese kelp farm led to lower electricity and fuel consumption compared to small-scale production. Thus, placing the Chinese farm on the lower end when comparing the carbon footprint. There was a large variation in carbon footprint per kg kelp, which implies that the kelp cultivation sector has a large room for optimisation. Evaluating large-scale cultivations allows for better evaluations of climate change mitigation potential as well as gives insight on both effective cultivation practices and the limits for optimisation.

Abstracts

Saccharina latissima cultivation in the Belgian part of the North Sea – challenges and lessons learned in preparation to move offshore

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Interest is high in using available offshore sites within wind parks for seaweed cultivation in European waters due to increased competition between different sectors for marine space. One aspect of the Belgian Pilot within the Horizon 2020 project UNITED (Multi-Use offshore platforms demoNstrators for boostIng cost-effecTive and Eco-friendly proDuction in sustainable marine activities) focuses on developing feasible cultivation techniques for the brown alga *Saccharina latissima* in these high energy environments. Six seaweed nets (6x3m and 4x2m) were installed during trials at the pre-operational test site – 5 km off the Belgian coast – over two growth seasons (2020/2021 and 2021/2022). Different substrates (nearshore/offshore and rope net type), seeding techniques (nursery versus direct seeding) and strains (originating from North France and The Netherlands) were tested. We identified seeding technique as a major factor determining yields. Over the first cultivation season, direct seeding resulted in very low density (max. 60 individuals m^{-1}) and yield (max. 0.5 kg m^{-1}) compared to net sections kept in a nursery for four weeks (max. 200 individuals m^{-1} and 1.1 kg m^{-1}). No differences were observed between different seaweed strains. Optimization of the nursery and adjustment of the direct seeding method resulted in higher yields in the second growth season. However, nets kept in the nursery before deployment still showed higher yields (max. 2.8 kg m^{-1}) compared to the adjusted direct seeding (max. 1.3 kg m^{-1}). Results indicate the need for optimized seeding techniques allowing for successful large-scale cultivation of *S. latissima* in highly exposed offshore conditions.

Abstracts

Lessonia corrugata aquaculture: seasonal cultivation and an innovative nursery approach

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Kelp farming is increasing in temperate regions globally, requiring knowledge of seasonal growth, alongside the development of approaches to improve sustainable kelp farming. Here, we studied the at-sea cultivation of *Lessonia corrugata* at different depths (1 m, 3 m, 5 m) and seasons. We also tested an innovative new nursery approach, where seeded spools were cultivated by spinning (SS) (relative to a control: not spinning (SN)) to increase the water motion and light homogeneity across seeded spools. In spring, *L. corrugata* had faster growth at 3 m and 5 m (8 ± 1.2 mm·day^{-1} and 7.5 ± 1.5 mm·day^{-1}, respectively) and up to 96% higher survival than in other seasons. In summer, 100% of kelps died at all depths. In autumn, *L. corrugata* had faster growth at 5 m (3.1 ± 1.8 mm·day^{-1}) and up to 42% survival, and a similar result was found in winter. In the nursery, sporophytes on SS seeded spools had a quicker development when compared with NS spools: blade size was 42 ± 8 mm and 25 ± 4 mm, and holdfast area was 0.1 ± 0.9 cm^2 and 0.03 ± 0.01 cm^2 for SS and NS, respectively. The spools were subsequently deployed at sea, and SS grew 60% more, and survival was 12% higher than for SN. We conclude that spring is the best season to deploy *L. corrugata* at sea at depths between 3 and 5 m and that spinning the seeded spools is a promising method to improve cultivation of *L. corrugate*.

Abstracts

Developments in algae-based biopolymers for food packaging applications

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Seaweed-based polysaccharides are extracted from a wide range of seaweed species and include alginate, agar, and carrageenan. These materials are highly versatile and can be utilised in numerous industries such as the pharmaceutical and food processing industries. The facile film-forming ability of the polysaccharides is conducive to the development of coatings and thin films for food packaging applications. In the area of coatings, seaweed biopolymers can be applied directly to fresh produce to extend the shelf-life by various mechanisms. Coatings derived from seaweed biopolymers can also be applied to paper-based packaging to create hydrophobic surfaces designed to replace conventional petroleum-based plastic coatings. Films derived from seaweed biopolymers are a major growth area in the field of food packaging materials. However, since these polymers are naturally hydrophilic, they exhibit limitations related to their barrier and mechanical properties. Recent developments in this area include the addition of nanoclays, nanocellulose, and carbon nanotubes to improve the overall film properties. Other films are incorporated with additives such as nanosilver and natural extracts to impart antimicrobial and antioxidant activity to extend the shelf-life of packaged foods. This presentation will provide an overview of recent developments in the use of seaweed biopolymers in the field of coatings and films for food packaging with an outlook on future trends and growth potential.

Abstracts

Development and characterization of enriched bioplastics made from whole seaweed and carrageenan for food packaging

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Recently, seaweed and its hydrocolloids were being promoted as ingredient for biodegradable plastics. In this study, bioplastics were developed from whole seaweed (*Kappaphycus alvarezii*) biomass (WS), semi-refined carrageenan (SRC) and refined carrageenan (RC). To enhance their properties, they were dyed using butterfly pea flower (*Clitoria ternatea L.*), bougainvillea flower; and dragon fruit (*Hylocereus polyrhizus*) peel extracts. The bioplastics development employed material-to-water ratio of 1:50; 2% (v/v) glycerol as plasticizer and 5% (v/v) natural dye. As results, the bioplastics were 0.03 – 0.100 mm in thickness which is in the range of commercial food packaging. Without dye, the WS, SRC and RC bioplastics has opacity (mm^{-1}) of 4.14 ± 0.45, 3.50 ± 0.30 and 1.63 ± 0.31, respectively; meanwhile colour difference (ΔE) were 29.6 ± 0.1, 14.2 ± 0.1 and 6.4 ± 0.1, respectively. RC bioplastic has the highest tensile strength (12.80 ± 0.90 MPa) and elongation-at-break (25.7 ± 0.5 %), followed by SRC (8.0 ± 0.4 MPa, 21.3 ± 0.6%) and WS (5.4 ± 0.7 MPa, 17.9 ± 1.0 %). No significant difference in water vapour permeability (WVP); WS degraded the fastest with all bioplastics fully degraded after 18 days; and shelf life (at 25^{O}C, 56% RH) up to 17 weeks. For the dyed bioplastics, the natural dye blended well into the natural colour of base material resulting in attractive shade. Mechanical properties, WVP and biodegradability were not significantly affected but shelf-life was 20 - 30% longer. Seaweed bioplastics have a potential as green alternative for single-use non-degradable food packaging.

Ulva lactuca biorefinery: protein extraction for aquafeed and leftover carbohydrates for production of biodegradable bioplastics

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Ulva lactuca, known as sea-lettuce, is a common macroalga associated with green tides in coastal areas. It contains approx. 35% polysaccharides and 15% proteins and its upgrade to valuable bioproducts is sought. Protein extraction from *Ulva* was carried out in a pilot-plant using a conventional, green method. Protein extracts were processed to produce a protein-rich ingredient to be included in aquafeed. The produced extracts were characterized in terms of peptide and amino acid profiles, and antioxidant activity.

Alternative carbon sources are being screened to decrease production costs of the microbial polyesters polyhydroxyalkanoates (PHAs). After protein extraction *Ulva* residues with 25-40% carbohydrate content can be used as a carbon platform for poly-3-hydroxybutyrate (P3HB) production. Glucose-rich liquors were produced from *Ulva* residues and used as C-source by the halophilic bacterium *Halomonas elongata* DSM 2581T to produce P3HB. This bacterium was selected for its ability to synthesize PHAs under high salt concentrations, allowing the use of open cultivations and potentially decreasing sterilization-related costs. A combined hydrolysis of acidic thermal treatment followed by enzymatic hydrolysis with cellulolytic enzymes, yielded a liquor with 10-12 g/L total sugars and negligible amounts of the microbial growth inhibitor 5-hydroxymethylfurfural. After a concentration step, the hydrolysate was assessed for P3HB production by *H. elongata*. Bioreactor (2L) cultivations in the fed-batch mode were carried using the hydrolysate from *Ulva* residues as feed. A maximum P3HB production of 9.7 g/L, 24.3% P3HB content and 0.25 g/(L.h) productivity were attained. Gluconic acid was observed to be simultaneously produced.

Seaweed Biopackaging Economics and Ethical Supply: How to achieve both with integrated product streams and Fair Trade Agreements.

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Seaweed Biopolymer applications are on the rise as demand for sustainable materials increases. Meanwhile, climate-affected coastal communities in developing nations are facedwith a new opportunity and a rapidly closing window to meet this growing demand while securing a fair share of the uplift. With declining fish stocks and marine habitats leaving fishermen without income in many nations, a significant pattern is emerging with women taking up seaweed farming. As the new breadwinners, female farmers are accounting for social uplift for their local communities with renewed investment in housing and education. Rapid scale up of seaweed cultivation and access to fair trade will be essential to securing the benefits of this rapidly emerging market.

Kelpy has developed two world first seaweed packaging innovations to replace single use plastics. 100% bio-derived, seaweed biopellets and granules designed for manufacture on standard plastics manufacturing equipment. Both the flexible film and rigid – injection mouldable packaging solutions have zero plastic and are home compostable. This is a truly circular product with sea to soil benefits. Yet, it's not enough. Our solution must be one of multiple product streams derived from biomass yields. Our team and partners are navigating fractionated models to include the extraction of higher value ingredients for food, cosmetics, biomedical, livestock supplements and biostimulants from the same biomass supply that we process into Kelpy pellets and granules. Offsetting these higher and lower value uses, coupled with Fair Trade Agreements will ensure the greatest outcomes for the farmers at the coalface of climate change.

Abstracts

Potentials and Feasibility of Seaweed Biopolymers

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Exploring alternative sources to produce biodegradable polymers has become most important because of environmental concerns regarding conventional plastic materials. Algae has the potential to provide renewable sources of industrial materials through the production of novel biopolymers. Starch, cellulose, agar, carrageenan, alginate, and xylan are notable examples of polysaccharides, which are bio-derived polymers from seaweeds. Seaweed biopolymers are non-toxic, biodegradable, renewable, biocompatible, and eco-friendly, gaining much interest in academic and business sectors due to their similarity to traditional plastics. Seaweeds have many advantages over other biomass because they can grow quickly, easily, and cheaply without using pesticides and not requiring a large amount of space. Seaweeds can be blended with other species or biopolymers to improve their qualities and properties, such as thermal, physical, and mechanical. They can also be used as fillers in various biopolymer composites. Producing seaweed biopolymer through green production methods is preferable to traditional extraction methods due to the environmental and economic benefits. Therefore, using seaweeds as biopolymers is a promising way to replace conventional plastic that is both cost-effective and eco-friendly.

Abstracts

Marine biodegradable and home compostable bioplastics derived from red seaweeds for packaging and single-use applications

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Plastics and microplastics continue to accumulate in our seas and oceans, threatening to irreversibly damage fragile ecosystems, posing severe health risks to marine wildlife, penetrating our food resources, and damaging coastal ecosystems. Given that nearly 50% of all plastics are for single use applications, there is a great opportunity to develop solutions that are designed to last the lifetime of use and then harmlessly degrade away under natural conditions. At Sea6 Energy, we have innovated technologies for cultivating red seaweeds at scale and manufacturing value added solutions from them. Seaweeds absorb carbon dioxide from the atmosphere and convert it into natural biopolymers which are compostable and marine degradable. Importantly, they have a very low carbon and energy footprint to manufacture biodegradable plastics compared to existing technologies. Red seaweed biomass was processed either via chemical modifications or blending with other natural compounds, to make bioplastic materials. Our patent pending technology allows us to make materials such as straws, sheets, sachets, coated paper sachets, multi-layer films, granules, etc which are functional for their lifetime of use but safely biodegrade afterward. Mechanical properties (tensile strength, load bearing capacity, tear resistance, etc), water interaction properties (hydrophobicity, water solubility, etc), and grease resistance properties were tuned to meet the requirements of specific applications. In addition, heat sealability, printability and biodegradability of the bioplastic materials was also demonstrated especially for single use packaging alternatives for food and non-food applications. Overall, red seaweeds represent a renewable and sustainable feedstock for developing bioplastics solutions.

A proteo-transcriptomic investigation of two life history stages for the red seaweed *Asparagopsis taxiformis*

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Emerging genomics for *Asparagopsis taxiformis* is has provided a strong foundation for in-depth molecular investigations, including proteomics. We investigated the proteome of *A. taxiformis* (Lineage 6 from Queensland, Australia) of both sporophyte and gametophyte (male and female) life history stages, using soluble and insoluble extraction methods followed by mass spectrometry. We identified several hundred of unique non-redundant proteins using a genome- and transcriptome-derived database. However, the transcriptome-derived proteins demonstrated numerous non-seaweed proteins such as those predicted to be of fungal origin. Given our focus on seaweed-specific proteins, we further investigated proteins identified from our own genome-derived protein database. Gene ontology analysis indicated that 19% were ion binding proteins (i.e., iron, zinc, manganese, potassium and copper), which may play a role in heavy metal bioremediation. In addition, we identified stress-related proteins (e.g. heat shock proteins and vanadium-dependent haloperoxidases) and numerous photosynthesis-related proteins (e.g. phycobilisomes, photosystem I, photosystem II and ATPase), of which, several were exclusively in female gametophytes. Finally, we identified 40 proteins that are predicted to be secretory. We report 10 newly identified rhodophyte proteins with high levels of gene expression. In summary, this overview of proteins expressed in *A. taxiformis*, across two different life history stages and between the sexes, highlights the potential for targeted protein purification for functional characterisation and applications as functional feed ingredients for livestock.

In-silico based omics approach to understanding *Asparagopsis*-organism interactions: implications for aquaculture and restoration

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The red seaweed *Asparagopsis taxiformis* is considered as a prospective feed additive due to its capacity to biosynthesise bromoform, a halogenated compound that interferes with the production of the greenhouse gas methane in livestock rumen. Therefore, there are currently efforts to grow this seaweed on a commercial scale, however, successful establishment of *Asparagopsis* aquaculture requires data elucidating the molecular basis of the response of this species to co-occurring organisms. To inform the development of this study, we conducted a systematic review assessing the current literature examining the molecular basis of seaweeds' response to co-occurring organisms with respect to types of interactions investigated, and the molecular methodologies that were applied. Of the 87 unique experiments conducted across 81 screened articles, majority assessed the response of seaweeds to herbivores (52%), pathogens (25%), and fouling organisms (11%); however, only 5% assessed chemically mediated response (allelopathy). Regarding the molecular methodologies, majority of the screened studies utilised metabolomics (75%) whereas transcriptomics and proteomics were merely utilised in 9% and 4% of the conducted experiments, respectively. We then screened the draft *A. taxiformis* genome (in preparation) for interaction-associated molecules using a combined *in-silico* omics approach and identified 345 putatively secreted (allelopathy consistent feature) biomolecules and 606 defense-related molecules inclusive of, but not limited to pathogen recognition receptors, ROS scavenging species, and potential defense effectors. In addition, a combined proteomics approach was employed to identify the presence biomolecules in *A. taxiformis*-conditioned seawater resulting in a peak-rich RP-HPLC profile and further characterisation of 3 novel proteins.

Abstracts

The effect of ocean warming and CO2 enrichment on *Ecklonia radiata*: investigating molecular responses

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Macroalgae form the foundations of diverse and productive coastal ecosystems but increasing carbon dioxide (CO_2) concentrations and ocean temperatures pose a threat to their survival and ecological function. The mechanisms underlying the physiological responses of macroalgae to the interactive effects of CO_2 enrichment and warming are poorly understood. This study investigates the molecular processes underlying physiological acclimation to better understand the potential responses of macroalgae to near-future climate change scenarios. Here we compared the physiological and gene expression responses of *Ecklonia radiata* to three different temperatures (6 °C, 16 °C, and 26 °C), and ambient and elevated CO_2. This study represents a significant step forward in understanding the underlying mechanisms in response to ocean global change and enhances our ability to predict the outcome of some macroalgal species.

Abstracts

In silico investigation of red algal metabolic pathways using a multi-omics database

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Red seaweed natural products and secondary metabolites are quickly becoming highly sought after materials. However, there is a dearth of knowledge on red algal metabolic pathways, and very few functionally annotated red algal genomes or transcriptomes compared to other organisms. To remedy this, a "multi-omics" database consisting of 29 genomes and 29 transcriptomes was created with organisms from 32 species over all 7 classes of red algae. This database contains genome and transcriptome assemblies, BUSCO analyses, custom repeat libraries, deduced protein sequences, orthogroups, phylogenetic trees, gene duplication predictions, and functional annotation.

Using this database, over 200 metabolic pathways were investigated. Core metabolic pathways such as the MEP, C10-C20 isoprenoid biosynthesis, and C3 photosynthetic pathways were conserved across all algae, while known fungal and bacterial secondary metabolite biosynthesis pathways were absent. Notably, complete CAM and C4 photosynthetic pathways were detected in 74.2 and 51.6% of macroalgal sequences, respectively, but only in 3.7% for both pathways in microalgae, implying a potential reduction of genes across microalgae relative to macroalgae. These results suggest the conserved evolution of core metabolic pathways, but missing genes across microalgae, corresponding with different evolutionary paths.

In summary, we created a database of functionally annotated red algal genomes and transcriptomes, larger and more comprehensive than any database currently publicly available. Using this database, we were able to perform a comprehensive *in silico* investigation of red algal metabolic pathways. We envision that this database and metabolic pathway data will be a strong and comprehensive resource for future algal research.

Abstracts

Proteomic analysis of the unicellular macroalga *Caulerpa lentillifera*

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Caulerpa lentillifera is a multinucleated unicellular organism showing complex morphological structures analogous to land plants. The morphological differences among structures in a *Caulerpa* cell seem to be determined by the preferentially localization of biological molecules such as RNAs or proteins. In our previous study, the comparison of transcriptomic profiles between two different structures of *C. lentillifera*, fronds and stolons, showed that over 1,000 genes were expressed preferentially in each structure.

Although there is limited knowledge of protein localization in a *Caulerpa* cell, our transcriptome analysis indicated that gene ontology terms associated with protein translation are enriched in the stolons. The results suggest a hypothesis that proteins in a *Caulerpa* cell are mainly translated in the stolon, then some of the translated proteins are transferred to other structures such as fronds. To investigate the hypothesis, we extracted toral proteins from *C. lentillifera* and identified the proteomic profiles using shotgun mass spectrometry. Unexpectedly, the results did not clearly support the hypothesis, however, preferentially localization patterns of the proteomic profiles were different from the patterns of the corresponding transcripts. In addition, some of ubiquitous expressed transcripts were preferentially localized as proteins in the fronds or stolons. These results suggest that the protein localization in *C. lentillifera* is regulated by the different mechanisms of RNA localization.

Abstracts

Effect of salinity on the physiology of the seaweed *Ulva* sp. in a tropical environment.

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Ulva is a euryhaline seaweed that has a worldwide distribution, being known for causing most of the green tides around the world and for being cultivated especially in estuaries. It is also economically important, ranking among the most farmed seaweeds. As climate change is linked to altered salinity gradients and salinity is a major driver in seaweed distribution, we subjected *Ulva* sp. thalli to growth in 15, 35, and 55 psu salinity, at a 12/12h photoperiod under 100 microMol photons, for 5 days. The wet mass of the thalli was sampled on days 1, 3, and 5. Each sample weighed 4 ± 0.2 g wet mass before any treatment. Our results showed growth rates of 28 ± 1.35 (at 15 psu), 10.34 ± 4.99 (35 psu), and 27.85 ± 2.85 (55 psu) after 5 days of treatment. We found no difference between the growth rates at 15 and 55 psu ($p = 0.72$), whilst at 35 psu growth rates were the lowest ($p<0.01$). Our measurements of photosynthetic rates showed no effect by salinity. Growth in low salinity and high salinity conditions was highest, and this as well as the photosynthetic rates not changing significantly with changes in salinity were in disagreement with the literature. Increased growth in low salinity coupled with *Ulva*'s ability to profit from disturbed environments might indicate the increase of harmful blooms in estuarine regions as well as increased farm yields as a consequence linked to climate change.

Safety in Seaweed; how to measure, mitigate and regulate.

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There is increased attention to seaweed cultivation in European waters to reduce dependency on imported biomass and as an alternative to terrestrial agriculture. Seaweeds are presented as sustainable, natural biomass. Yet, there are concerns about how food safety is considered, limits to ecosystem carrying capacity, and occupational health and safety. If not implemented well, these could hamper sector development or result in irreversible damage to the natural system or human wellbeing. A shared view on the relevance, assessment and mitigation of risks can help bring the seaweed sector further.

The Safe Seaweed by Design project aimed to support the seaweed sector in dealing with safety issues. Based on a literature study, interviews, surveys, and a pilot, the project identified key safety aspects and developed protocols to assess, prevent, and mitigate risks.

Given the diversity of seaweed species, production locations, methods and applications for harvesting and analysis, among other factors, there is a multitude of perspectives and points of views to consider safety. Our project delivers a generic protocol highlighting key safety issues when cultivating seaweed. Methods to assess the most relevant risks on a case-by-case basis are presented. This includes suggestions for real-time monitoring, using remotely operated vehicles to evaluate benthic impacts, and sampling and analysis for food safety contaminants and environmental impact. Considering the diverse safety needs, we recommend that those responsible for licensing, policy and/or regulatory compliance communicate and work together with sector stakeholders to support safety. Our results will be presented and can be used by the seaweed sector to ensure safety is taken on board in the sector's future development.

Can certification based on credible international standards help shape the growing seaweed industry?

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Increasingly, seafood producers are adopting an approach of positive reinforcement by clearly identifying and demonstrating legitimate and sustainable production that has minimal impact on the environment. Seafood certification programs like the Marine Stewardship Council (MSC) and the Aquaculture Stewardship council (ASC) provide one such mechanism.

The MSC and ASC released a joint seaweed standard in 2018 realising the uniqueness of seaweed production and focussing on both environmental as well as social aspects. Apart from regulators which focus on monitoring, control and surveillance, voluntary standards like the MSC and ASC can be most impacting, as they are effective in the marketplace.

Drawn from our group's collective 20+ years in the seafood certification industry, we will explain the assessment and certification process at a level that will allow

Producers and supply chain actors to assess operational characteristics and market environments that lend themselves to the successful adoption of such schemes;

Producers and supply chain actors to prepare their operations, staff and stakeholders, in order to most effectively and efficiently navigate the process;

Regulators and policy makers to understand their role, and how to effectively support industry in certification aspirations, and

Industry and government to understand the ways to enhance the benefits and values of certification.

Abstracts

Case Study of ASC-MSC Seaweed Sustainable Certification Program in Korea and Market Opportunities

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The Marine Stewardship Council (MSC) and the Aquaculture Stewardship Council (ASC) are international non-profit organizations that have the objective of protecting the oceans and safeguarding the seafood supply for the future. MSC and ASC published the ASC/MSC Sustainable Seaweed Standard in November 2017 and then the certification program was launched officially.

As a result, 6 organizations including individual seaweed farms, cooperatives, and associations have obtained certification and currently distributed certified seaweed products on the market. Interestingly, 4 out of a total of 6 certificate holders are Korean seaweed producers. Therefore, it is very meaningful to understand their interest to engage in the program as well as to identify major challenges they encounter during the certification process.

The ASC/MSC sustainable seaweed certification program is based on multi-stakeholder governance consisting of seaweed producers, research institutes, retailers as well as government and non-government organizations. Hence, these stakeholders' engagement has a huge positive impact on fishery practice and consumer awareness. In addition, it encourages suppliers to participate in this program by providing market incentives to producers as well as by promoting responsible consumption to consumers.

The number of seaweed farms participating in this program around the world has continued to increase and consumer demand for purchasing ASC/MSC eco-label products has also consistently raised.

For this reason, this study aims to find out whether the certification program will be successful in the Korean seaweed industry through in-depth interviews furthermore identifying the practical advantages and improvements that the certificate holders can obtain from this program.

Abstracts

From Garage to Greatness, a NZ Seaweed Story

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In 1996 teachers, Jill Bradley and Keith Atwood relocated their family to small town New Zealand in search of seaweed after a working vacation on organic farms. Nearly three decades later, their son Tane and his wife Clare Bradley operate the business once known as Ocean Organics, now AgriSea, which creates liquid concentrates from the local seaweed *Ecklonia radiata*.

The company has grown from a garage hobby to a thriving national business in and exporting across the globe. This growth has been measured and steady, primarily due to the lack of NZ seaweed resource available in a sustainable manner.

For the past 26 years, AgriSea has relied on "beach cast" (seaweed washed upon the shore) after storms, however recent project partnerships means that AgriSea can start supporting both on-land and in-sea aquaculture of seaweed to feed into its value chain.

AgriSea are committed to being players in a bicircular economy and have partnered with New Zealand National Research agencies to develop high value products from its waste stream including nanocellulose hydrogels and extracts along with utilising the nutrient rich waters created from New Zealand's farming and fertiliser management systems to grow seaweed.

Innovation and collaboration are not just buzz words for AgriSea they are in the families DNA. Building on networks around the globe they have many partnerships which span everything from seaweed gin to biomaterials, recently winning the NZ Hi-tech awards category for Māori company of the year.

Abstracts

A National Framework for a Sustainable Seaweed Sector in New Zealand

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New Zealand has a rapidly evolving seaweed sector with innovation operating at a small scale, constrained by an underdeveloped supply chain and a regulatory framework that is not fit for purpose. A project funded by the *Sustainable Seas National Science Challenge* has developed the framework for a sustainable seaweed sector. Its purpose is to:

> *guide the development of a thriving, high-value seaweed sector that provides meaningful economic, environmental, social, and cultural benefits.*

The project has reviewed the current state of the seaweed sector in three research outputs:

A. Stocktake and characterisation of New Zealand's seaweed sector: market and regulatory focus.

1. Species characteristics and Treaty of Waitangi considerations.
2. Environmental effects of seaweed wild-harvest and aquaculture.

The research was reviewed with stakeholders and summarised into an overarching framework, incorporating:

- Priority Markets and Value Pathways
- Supply Chain Priorities
- Business Models & Investment
- Sector Development Risks
- Regulatory Priorities
- Knowledge Priorities
- Sector Leadership Priorities

A pragmatic, phased strategy for New Zealand seaweed producers will focus on unmet demand in existing markets, progressively developing higher value products where technology, scale, investment, and intellectual property permit. Priority markets for NZ seaweed product and services include health & beauty; human food; animal feed supplements, biostimulants, and ecosystem services. Each market has product pathways to higher value, and some have significant unmet demand due to seaweed supply chain constraints. Priority local species for supply vary according to the target market. Significant constraints to sector development and responses have been identified for the supply chain and supporting building blocks.

Abstracts

How do seaweeds acquire their microbial symbionts?

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Seaweeds host many bacterial symbionts that are essential for health and performance. How these bacteria are acquired is however poorly understood. This study evaluated the presence of bacteria on the gametes of different seaweed species, including *Ulva australis, Delisea pulchra, Hormosira banksii* and *Phyllospora comosa*, using fluorescence *in situ* hybridization, scanning electron microscopy and 16S rRNA gene sequencing. No bacterial cells were detected on spores of *U. australis* showing a lack of vertical transmission of bacterial symbionts and thus indicating the need for symbiont acquisition from the surrounding seawater. In contrast, bacterial cells were visibly attached to the surface of *D. pulchra* tetraspores and the eggs of *H. banksii* and *P. comosa,* demonstrating the potential for vertical transmission. The bacterial community structure and composition of *D. pulchra* and *P. comosa* adults resembled those of their gametes, indicating a non-selective transfer of symbiont. In contrast, the bacterial communities associated with *H. banksii* eggs were significantly different from parental thalli, indicating a selective symbiont transmission. This study revealed species-dependent processes of symbiont acquisition in seaweeds ranging from selective and non-selective vertical transmission from parents to horizontal transmission from the environment.

Salinity structures the microbiome of the green seaweed Ulva: functional and taxonomic patterns

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The green seaweed *Ulva* is a model system to study seaweed-bacteria interactions. Although it becomes increasingly clear that microbes are of vital importance to their algal host, the impact of environmental drivers on the dynamics of these interactions is little understood. Assessing microbiome changes across an environmental gradient may provide information on the redundancy of the associated bacteria and the relative importance of stochastic vs. deterministic mechanisms of the community assembly. We investigated the stability and variability of *Ulva*-associated bacterial communities across the stable Atlantic-Baltic Sea salinity gradient. Using the full-length 16S rRNA gene, generated with Oxford Nanopore sequencing, we taxonomically characterized the bacterial communities of 15 *Ulva* sensu lato species along 2000 km coastline in a total of 481 samples. In addition, we functionally characterized a subset of 92 samples with Illumina shotgun metagenomic sequencing, resulting in 656 MAGs (metagenome-assembled genomes). Our results demonstrated that *Ulva*-associated bacterial composition and functional gene composition were strongly structured by both salinity and host species. The largest shift in the bacterial consortia coincided with the horohalinicum (5-8 PSU, known as the transition zone from freshwater to marine conditions). We defined distinct low and high salinity bacterial communities, as well as identified a small core community (contributing to 14% of the reads per sample, on average). Our results contradict earlier statements that *Ulva*-associated bacterial communities are taxonomically highly variable across individuals and largely stochastically defined. Characteristic bacterial communities associated with distinct salinity regions may therefore facilitate the host's adaptation across the environmental gradient.

The green seaweed *Ulva* and its microbiome in a changing environment: insights for new applications

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The marine green seaweed *Ulva* (Chlorophyta) coexists with a diverse microbiome. Many *Ulva* species proliferate and form green tides, which occur when nutrient-rich wastewater is flushed into the sea. Hereby, bacteria are required for *Ulva*'s adhesion to its substrate, growth, and the development of its thallus morphology. When compared to freshly isolated algae, the microbiome gardening of *Ulva* reduces the operational taxonomic units in aquacultures, indicating a selection process. Under axenic conditions, however, *Ulva mutabilis* develops a callus-like morphotype.

While bacterial strains of the *Roseobacter*-clade cause blade cell division, bacteria of the genus *Maribacter* promote differentiation of basal cells into a rhizoid and support cell wall formation through the morphogen thallusin (EC_{50} = 4.8 pM). Interestingly, a reductionist tripartite community of *Ulva* with two essential bacteria can restore the entire morphogenesis. The tripartite *Ulva* community now serves as a model system to study, for example, what the associated bacteria need for the holobiont to withstand environmental stresses and develop into a multicellular organism.

Macroalgae may adapt to changing environments in two ways: (i) through intrinsic changes in algal metabolism caused by differential gene expression and metabolite production; and (ii) through extrinsic changes provided by the associated and stress-adapted microbiome caused by its continuous support with algal growth and morphogenesis promoting factors (AGMPFs). This talk will focus on recent research and discuss how *U. mutabilis* has evolved into a model organism in chemical ecology, taking advantage of the specific perspective that a reductionist model system allows and discussing possible applications.

Abstracts

Unravelling the effects of microbiome manipulation in cultured *Asparagopsis taxiformis*

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Asparagopsis farming is set for major global expansion because of the effect of its halogenated compounds on methanogens when fed to cattle. However, some of the earliest work on this genus involved basic research into how these antimicrobial compounds benefit the seaweed itself by controlling the microbiome. In a systematic review, we show that after this brief window of research, which produced 35 papers on culture, microbes, and chemistry in the 1950-70s, most of the recent work has focussed on the addition of *Asparagopsis* to cattle feed and its cultivation for the same application (130 publications and counting). None of the current cultivation work has linked production constraints to the control of the microbiome and/or the importance of morphogenesis-promoting factors. These could be crucial for the healthy development of *Asparagopsis* in nature and in culture. In this study, we demonstrate that domesticated sporophytes have very specific microbiomes when compared to wild ones, and we explored the effects of microbiome manipulation using antibiotics on the growth rates of fast-growing seaweed cultures (weekly SGR 5%, >3 months). 16S rRNA gene sequencing and fluorescence microscopy were used to quantify the microbiome impacts. Different bacteria from the surface of the seaweed were identified by Sanger sequencing, including strains from *Alteromonas* and *Roseobacter* genera. We present the growth effects of various bacterial strains when reinoculated onto *A. taxiformis,* as well as their impact on the production of the halogenated compounds. These are discussed in the context of the future success of farming enterprises.

Abstracts

Bacterial controlled mitigation of dysbiosis in a seaweed disease

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Delisea pulchra is a red seaweed residing in the subtidal regions of the south-eastern coast of Australia. It suffers from a bleaching disease caused by high-temperature stress and the activities of opportunistic pathogens. Our studies identified over 30 isolates that were antagonistic against bleaching pathogens, including a TDA-producing *Phaeobacter* sp. BS52 that can increase the disease resistance of *D. pulchra* by mitigating the pathogen-induced shifts in host-associated microbiota (i.e., preventing dysbiosis). Further, a phylogenetically closely related strain *Phaeobacter* sp. BS23, has neither protective nor pathogenic effects towards *D. pulchra* and did not prevent the pathogen-induced dysbiosis. These findings indicate that *Phaeobacter* spp. have species- or strain-specific ecological roles in the bleaching disease of *D. pulchra*. To identify functions underpinning this phenotypic variation, we sequenced, and *de novo* assembled the whole genomes of *D. pulchra* protective BS52 and two representative commensals *Phaeobacter* spp. BS23 and BS34. Phylogenomic analysis designated the strains BS52 and BS23 to species *Phaeobacter piscinae* and BS34 to *Phaeobacter inhibens*. Using comparative genomic analysis, the study identified putative functions such as phage infection and antibiotic production that may contribute to the protective ability of BS52. This study highlights that subspecies level variations can lead to different disease protective phenotypes in *Phaeobacter* spp. It is hoped that these findings will benefit future probiotics discovery and disease management in seaweeds with applications for conservation and aquaculture.

Abstracts

Preliminary Study on the Bacterial Infection occurred in Tank-cultured Sea Grapes, *Caulerpa lentillifera* J. Agardh (Bryopsidales, Chlorophyta)

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Sea grapes, *Caulerpa lentillifera*, are a type of green seaweeds that play an important role in aquaculture production and have been used for centuries as human food. Due to high demand, the cultivation of sea grapes has expanded not only in Sabah but also in peninsular Malaysia. The increasing cultivation of *C. lentillifera* has led to increases in disease, particularly bacterial invasion. Disease can impact quality and production of *C. lentillifera*. However, little is known about the structure and diversity of the microbial community in *C. lentillifera.* Furthermore, particularly in Malaysia, there is lack of information and research on bacterial infection and disease in cultivated *C. lentillifera*. Thus, the purpose of this study is to identify the possible bacterial infection that occurred in tank-cultured sea grapes, *C. lentillifera* using two types of culture systems (Recirculating Aquaculture System, RAS and static system). For this study, *C. lentillifera* was bought from the Filipino wet market (transported from Semporna Sabah) in Kota Kinabalu. The possible bacteria were isolated using two types of culture media, Tryptone Soy Agar (TSA) and MRS Agar. Several tests were used to purify and identify the possible bacteria, including gram staining, catalase test, and oxidase test. The result indicated several types of species identified as the possible cause for bacterial infection in *C. lentillifera* that has been compared with the previous study which were *Vibrio* sp. and *Cytophaga* sp., (related to the "ice-ice" disease and "rotten thallus syndrome") as well as *Flavobacterium* sp., *Psychrobacter* sp*., Psychromonas* sp*., Bacillus sp., Pseudoalteromonas* sp., *Pseudomonas* sp., *Oceanobacillus* sp. *Xanthomonas* s*p.,* and *Achromobacter* sp. that also found in the tank-cultured *C. lentillifera*. Among all the samples, bacterial colony counts of sea grapes samples in RAS, detected in MRS agar was higher (23.033 ± 10.595) compared to static system. Deeper study is required to further identify the bacteria species using molecular techniques, biochemical test, or PCR amplification of 16S rDNA.

Steam explosion: a novel route for high value compound release from nuisance *Ulva* species

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Due to the wide composition variation within macroalgae there is an equally vast potential to optimally process macroalgae to produce a range of extracted compounds, including through the application of suitable thermal processing for specific macroalgal genera and classes. This presentation falls within a mini-symposium examining a range of thermal processing methods and focusses on steam explosion of nuisance bloom green macroalgae *Ulva spp*. These algae contain high proportions of the valuable and unusual sugar rhamnose which preliminary studies have shown can be released following extractions using heat and pressure via an autoclave. This talk will present data generated following a range of variable-conditioned autoclave extractions including using standard and alternative pre-treatments of sulphuric and phosphoric acid respectively to enable comparisons with similar processing literature. It will then present scaled-up data based on this extraction method using Aberystwyth University's pilot-scale steam explosion rig, capable of operating at significantly higher pressures and more exact retention times. Quantification of rhamnose and other sugars in the solid and liquid fractions will provide data on efficiency of conversion under each condition. Steam explosion of green macroalgae is a highly novel combination with only one paper identified to date peripherally conducting this work; so findings from this study will be highly novel.

Abstracts

The role of hydrothermal treatment in the extraction of high value fucoidan from macroalgae

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Brown macroalgae offer a large potential source of biomass for the generation of sustainable energy, platform chemicals and bioactive compounds. However, the scale-up of this industry is dependent on identifying suitable technologies which can effectively process macroalgal biomass to facilitate extraction of target compounds or conversion into a suitable energy vectors. Subcritical water processing has been identified as a rapid and environmentally-friendly hydrothermal conversion technology which involves the conversion of biomass in hot compressed liquid water. Higher-end hydrothermal processing temperatures (150-250°C), termed Hydrothermal Carbonisation (HTC), facilitates the conversion of macroalgae to energy vectors. Alternatively, less-severe hydrothermal processing (100-180°C) can be utilised as a method of extracting high-value compounds from macroalgae, such as fucoidan. However, varying the reaction severity influences both the yield and characteristics of fucoidan extracts: influencing downstream applications. This aim of this study is to investigate how the yields and properties of fucoidan extracts vary according to different hydrothermal reaction severities. Extractions were conducted for three species of Fucales: *Fucus serratus, Fucus vesiculosus, Ascophyllum nodosum*, using a 45mL Parr reactor across a range of temperatures (100-180°C), retention times (5-15 min) and solid loading ratios (0.05-0.1 g mL^{-1}). The effect of process severity on fucoidan yields and properties will be discussed, alongside the potential opportunities for energy valorisation of process residues.

Microwaves and seaweed: a novel thermal processing technology that can be implemented within seaweed biorefinery concepts.

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Microwave heating has attracted much attention in recent years due to the advantages associated with dielectric heating. This includes the ability to overcome heat transfer limitation effects that are traditionally associated with conventional heating, resulting in higher heating rates, faster processing times, and the ability to efficiently control the heating environment. Importantly, due to the instantaneous volumetric heating attributes associated with microwaves, the potential to produce a range of different products from biomass resulting from unique thermal gradients is feasible. As such, the potential to incorporate microwave heating within a seaweed based biorefinery is promising. Nonetheless, research on this topic is still relatively sparse and the compatibilities of the technology for seaweed biorefining require further understanding to maximise value of this feedstock. The present research will explore the suitability of applying i) microwave pyrolysis and ii) microwave extraction within a biorefinery process using the UK native brown kelp *Laminaria digitata.* Specifically, understanding how the effects of microwave specific energy and power influence the production of pyrolysis bio-oil and bio-char, and the extraction of alginate and fucoidan are discussed, and thereby the potential application of these products of value across different industries.

Abstracts

Macroalgae, blue carbon and nature-based solutions

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Macroalgal habitats are recognized as being the most extensive and productive of all coastal vegetated ecosystems and there is growing attention on their contribution to carbon sequestration in addition to their importance for biodiversity. Yet their global extent and production, which is fundamental for quantifying their importance, have remained poorly assessed and there is still limited data on their contribution to carbon sequestration. I will present results from group efforts over the past few years to address these knowledge gaps. We have conducted a first data-driven assessment of the global extent and production of macroalgal habitats based on modelled and observed distributions and net primary production (NPP) across habitat types. We find that macroalgae extend across a global area of 6.06-7.22 million km^2 and represent a production of 1.32 Pg C annually. This matches the extent and production of the Amazon rainforest. The potential for macroalgal production to be sequestered as blue carbon depends on the lability of the organic matter as well as the transport to a carbon sink beyond the habitat in either fjord- or shelf sediments or in the deep sea. And fingerprinting methods are needed to document the macroalgal origin of the carbon. I will give examples of such efforts to quantify and document macroalgal C-sequestration and discuss potentials and limitations. Due to the positive effect of macroalgae on biodiversity and carbon sequestration, management actions to protect and restore these habitats and sinks may contribute as nature-based solutions to counter the combined biodiversity and climate crisis.

Supporting community-led restoration of kelp forest ecosystems and associated fisheries

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Natural resource and environmental management by indigenous people is often based on intergenerational goals that includes an ecosystem wide focus. In New Zealand, Customary Protection Areas (CPA) provide a legislative framework to allow for local management of fisheries by Iwi (tribes). Here a working partnership between researchers and Tangata Tiaki (customary fishery managers) from the Ngāi Tahu tribe is shared. This partnership called Te Tiaki Mahinga Kai (meaning looking after the food gathering areas and practices) primarily provides data that supports protection and restoration of fisheries, practices, and rights of Ngāi Tahu. While restoration of fisheries for the cultural keystones like the pāua (abalone, *Haliotis iris*) is often a focus, kaitiakitanga, a form of stewardship applied by Tangata Tiaki, values and acknowledges the role of all living things. This holistic approach understands the foundational role of seaweed in these ecosystems. Today a transition of in water leadership from scientists to the community is occurring and projects restoring *Macrocystis pyrifera* forests and controlling the invasive kelp *Undaria pinnatifida* are the focus for this process. Sharing the benefits of research and restoration programmes with communities is central in developing true partnership models and supporting future focused restoration of coastal ecosystems.

Abstracts

Asparagopsis exposé: 50-odd years of unique science and marketing

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Is *Asparagopsis* the most famous seaweed in the world? There are no others for which industry and news anchors alike are sidling through the phonetics of a genus name in the boardroom and on our screens. The work over the last decade since the discovery of its anti-methanogenic effect has forged collaborations across land and sea, advancing knowledge and venture capital. But *Asparagopsis* has always been special. Stepping back in time, so we leap forward in thinking, this talk will be an *Asparagopsis* highlights package. With humble beginnings, the *Asparagopsis* gametophyte was once considered a different genus to its *Falkenbergia* sporophyte. In the 1960s, its remarkable gland cells were front and centre, helping with taxonomy, and subsequently identified as a curious source of antibiotics in the 1970s. This decade saw the description of halogenated natural products in *Asparagopsis*. It included early interactions with bromoform, plus hundreds more compounds, some we are still uncovering today. In the 1980s came the realisation of its commercial potential in cosmetics, with the first sea-based farming and more laboratory culture work. The 1990s was a recession, of sorts, except for reproductive insights, but the 2000s saw an *Asparagopsis* renaissance with more chemical ecology, more bromoform and land-based farming, plus exciting insights on genetics and invasiveness. As for today, contemporary science can meet the technical challenges of farming and processing, but with so much to still understand on its ecology in changing environments, will environmental and other factors be the ultimate levellers for scaling *Asparagopsis*?

The international market for next generation seaweed products and applications - Findings from Hatch's global seaweed report

Author: Hatch Blue with funding from The World Bank Group and The Nest Family Office

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The seaweed industry produces >1/4 of total aquaculture output and with investment in more climate resilient technology, the sector is scalable. However, existing markets are only growing at 3-5% annually - too low for the seaweed industry to make a significant contribution to Sustainable Development Goal targets. To meet global objectives, sustainable seaweed mariculture as well as new markets for seaweed biomass have to scale. As part of our global seaweed report, Hatch has assessed market opportunities of novel products and applications from seaweed biomass. This work identifies new short, medium and long - term market entry points for seaweed application across a number of industrial sectors, such as Animal feed, Bioplastics, Biostimulants, Fabrics, Construction, Biogas, Nutraceuticals and Pharmaceuticals. Matched with our in-field research across the major seaweed producing regions globally to analyze the current state of seaweed supply, a gap analysis will outline current technology constraints and highlight innovation opportunities and investment needs.

The International Seaweed Symposium will provide the first stage to share our preliminary findings of this work with the global seaweed community. By providing information relevant to the decision making of the public and private sector, Hatch, the World Bank and the Nest Family Office hope to catalyze the adoption of innovation all along the seaweed value chain.

Abstracts

Genomic and genetic resources to accelerate breeding of brown seaweeds

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Seaweed aquaculture is increasingly attracting interest in Europe and the USA as a potential means to increase future production of food and biomass. Efficient expansion of seaweed cultivation to meet this objective will require the implementation of modern breeding strategies to improve yields and crop resilience. We have been developing several resources that are relevant to this objective. First, the large-scale brown algal genome sequencing project Phaeoexplorer (https://phaeoexplorer.sb-roscoff.fr/home/) is generating genome sequence information for several species of interest for aquaculture. These genomes represent essential reference sequences for future breeding programs. Second, recently established resources for the model brown alga *Ectocarpus*, in particular CRISPR-based gene editing, now make it a powerful tool for the analysis of gene function. Experimentally validated information about gene function obtained using this system will also be extremely useful to help target breeding approaches. Finally, focusing on the sugar kelp *Saccharina latissima* as a target aquaculture species, we have been establishing a range of resources including a large collection of RAD-seq genotyped gametophyte strains and protocols for the application of quantitative trait locus analysis and genome-wide association studies. The presentation will provide an overview of these approaches and will discuss their integration into seaweed breeding programs.

Abstracts

Selectively breeding improved strains of Sugar Kelp, *Saccharina latissima*; a four year summary

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Seaweed farming in the Gulf of Maine has expanded rapidly over the past decade. As part of ARPA-E's MARINER program, we have conducted a selective breeding program to improve the productivity and composition of sugar kelp, which could serve new markets for food, animal feeds, bio-products, and eventually biofuels. We maintain about a thousand monoclonal gametophyte cultures that can be used as parents for generating crosses. Kelp crosses were planted in "common garden" farm arrays over four seasons (2018 through 2022) in New Hampshire, USA. A summary of trait measurements and analyses of yield, composition and morphology for 1,008 family plots and over 12,000 individual kelp blades will be presented. One highlight is that several plots exceeded 20 kg/m harvest wet weight with the top plot weighing 28 kg/m or 4 kg/m dry weight – about 4 times the commercial average. We have used pedigree, genotypic marker data, and harvest phenotypes to estimate breeding value of parents and predict offspring performance. Ultimately, we are meeting goals of improving yields of dry matter per unit area more than 20% per generation. We have sequenced the whole genome of ~500 parents, tested their crosses, and phenotyped harvests to begin building a publicly available database for cooperative breeding (sugarkelpbase.org). We have also completed an annotated reference genome for sugar kelp that enables the identification of natural mutations on targeted genes to potentially create non-reproductive sporophytes. Using sterile sporophytes open opportunities for more productive farms while protecting natural genetic diversity

Genetic tools for selection of heat tolerant cultivars of *Saccharina latissima*

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In Europe, the development of *Saccharina latissima* farms and biorefineries relies on the ability to cultivate improved cultivars that express desirable traits. To maintain genetic diversity/balance in natural populations surrounding seaweed farms, the cultivation of improved, diversified crops should rely on the identification and selection of interesting progenitors from local populations. To facilitate this we need work with local germaplasm to select desirable traits in a cost- and time-effective way. Since the mid-80s, the development of genetic molecular markers associated with genes or quantitative trait loci (QTL) of interest has made it possible to apply Marker Assisted Selection (MAS). One of the aims of the European Union GENIALG project was to identify the loci underlying desirable selectable traits. We applied a QTL approach to a segregating family derived from a cross between local strains to map heat-stress response using a segregating family derived from a cross between local strains. One hundred and twenty-nine individuals were derived from the cross between two sporophytes belonging to two differentiated genetic groups from Northern and Southern Brittany, respectively. The progeny was phenotyped for heat stress tolerance and resilience. The progeny showed diverse responses to heat stress: tolerance, sensitivity but also diverse abilities to recover following stress treatment. To further investigate these responses, we conducted RNA-seq to identify genes responsive to heat-stress. The results of this work will allow us to better understand the genetic basis of heat tolerance and resilience and provide tools to identify wild individuals carrying alleles or expressing genes that confer good tolerance and resilience.

Abstracts

Development of Genetics Based Selective Breeding of Sterile Giant Kelp

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Macrocystis pyrifera (giant kelp), a brown macroalgae, is a keystone species that establishes forests in the subtidal zone, providing habitat for hundreds of different species, including other algae, invertebrates, fish, and mammals. Giant kelp also holds economic value as a major source of alginate, food, and molecules used in pharmaceuticals and cosmetics. Giant kelp also has potential as a feedstock for biofuel production, as it grows quickly and contains little cellulose or lignin. However, the promise of giant kelp as a major economic force is limited due to a lack of global production when compared to other economically important brown macroalgae such as *Saccharina japonica and Undaria pinnatifida*. While giant kelp domestication efforts have recently begun, present environmental concerns of invasive species and trans gene flow between wild populations and kelp farms have slowed and sometimes prevented the expansion of giant kelp farms. We propose a novel breeding program that leverages the haplodiplontic life cycle of giant kelp that directly addresses these environmental concerns. Using the emerging giant kelp genomic toolkit, we have scanned a germplasm consisting of 550 haploid giant kelp gametophytes for mutations that affect the meiosis pathway. As giant kelp gametophytes can vegetatively propagate under specific culture conditions, we have maintained our scanned genotypes for test crosses of two individuals with mutations in genes involved in meiosis. We are currently growing trial crosses of sporeless giant kelp selected from our germplasm. These findings should be applicable to other species of brown macroalgae in the future.

Biphasic selection domestication in giant kelp.

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In selective breeding, application of several recurrent steps is required, such as recombination, genotyping, and selection. In most plants, these stages are implemented in diploid individuals, although some exceptions – like phenotyping of monoploids – are also practiced. For sugar kelp and giant kelp domestication programs germplasm development and genotyping have already been moved to the gametophyte stage, i.e. microscopic haploid stage, easing resequencing and SNP calling. Current breeding programs have practiced phenotyping and selection at the sporophyte stage, which we now propose to supplement with much cheaper and high throughput phenotyping at the gametophyte stage. As this stage exhibits vegetative growth, this could enable massive but cheap phenotyping. Here, we have used a range of genotypes to determine whether those growing fast as sporophytes, would also grow fast as gametophytes. Indeed, strong concordance has been established. We propose agar-based plates and genomic models optimizing selection response via selection at gametophyte, then verification at sporophyte stages.

Abstracts

The USA MARINER Program: Opportunities for the future expansion of scalable aquaculture and breeding programs

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After more than three and a half decades of effort by scientists, industry, state and federal agencies, seaweed aquaculture offers new opportunities for expansion in US coastal waters. With the nursery technologies developed at the University of Connecticut, the cold-water brown seaweeds, *Saccharina latissima* and *S. angustissima* have been successfully cultivated in open water farms in the Northeast. Our selectively bred kelp grew as much as 7.0 m in length and yielded up to 28 kg FW per meter after 6 months with a density of >400 plants per meter. Typical commercial yields are 4 to 8 kg FW per meter. Seaweed aquaculture provides ecosystem services by removing excess nutrients (carbon and nitrogen) from ecosystems and thereby improves water quality, potentially reducing ocean acidification and creating opportunities for carbon sequestration. Kelp aquaculture in Northeast America can remove up to 180 kg N and 1800 kg C per hectare per year, depending on the spacing of the longlines and cultivation arrays. After more than $60 million invested by the ARPA-E (US DOE) MARINER Program, seaweed aquaculture is developing new business opportunities in the US. With improvements in productivity, kelp and other farmed seaweeds continue to build significant value as foods for human consumption and could potentially be viable feedstocks for animal feeds, phycocolloids and biofuels. There are unique opportunities for phycologists to work with ocean engineers, plant breeders and others to develop and apply advanced breeding technologies that will increase growth and production for open water farm systems in the US.

Blue Economy: Social Media, seaweed cowboys, hype and hoopla

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The Oceans are of crucial importance for human survival and hence the Blue Economy concept has been established. Nevertheless, global warming and overfishing threaten Earth's largest habitat, not to mention the plastic crisis. Phytoplankton responsible for about 50% of the oxygen in our atmosphere also sequesters carbon by sinking (when dead) to the deep sea, making phytoplankton an important actor in Earth's climate system. Lately, macroalgae have entered the mix, with wild promises of farming, upscaling, and climate solutions by sequestering CO2. Indeed, seaweed cultivation can capture more than what a rain forest will do, making it a good candidate for carbon capture. But carbon capture is not sequestering rather it is transfercation, moving CO2 from one source to the next till it gets released again. Sinking seaweed to the deep sea? We have little understanding of what will happen and all very much dependant on species grown, geographical location, currents and on top using fossil fuels to move the biomass. A lot of factual incorrect statements have been used lately and large amount of money invested on false promises. No standard equation exists for carbon off setting using seaweed and a lot more data and scientific insight is needed. If we scale up cultivation, why not use the biomass for a sustainable polysaccharide industry, compared to fossil fuel polymers industry and tackling issues like our plastics problem creating biodegradable plastics. All coming back to my old mantra; we have to move from a hydrocarbon to a carbohydrate society.

SEAweed-Tech: A green, sustainable, zero-waste technology for seaweed bio-refinery and bioplastic

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Southeast Asian countries produce 5 million metric tonnes of plastic waste each year which has a profound impact on marine ecosystems. Marine pollution also threatens the livelihoods of over 50% (~3.35 million) of the globe's artisanal reef fishers that live in Southeast Asia, compounding the detrimental effects of ever-declining fish stocks due to overfishing. Guided by our social conscience, and harnessing our unique expertise in algae biotechnology at the University of Technology Sydney (UTS), we teamed up with COAST4C to build a bio-economy to incentivize coastal communities in the Philippines to restore their marine environment. Together we are developing a novel green, sustainable, zero waste, and cost-effective technology for seaweed bio-refinery and seaweed-based biodegradable plastic production using green solvents. The deep eutectic solvents-based seaweed processing (DES) improved the de-sulfation and enhanced the yield and quality of carrageenan. Moreover, efficient recyclability and recovery of DESs after biomass pre-treatment and extracting fine chemicals from the residual biomass made the technology cost-effective for their use in seaweed-based bio-refineries. Therefore, the development of such green and sustainable technologies promises to provide a local solution to a local problem of marine pollution and poverty and to empower local communities to safeguard their marine estate.

Abstracts

Ready to go big? Scaling and quality issues for European cultivated seaweed for food

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After more than a decade of small and pilot scale cultivation of seaweed in Europe, interest from the food industry in this healthy and sustainable resource is finally growing and reaching levels where supply is struggling to keep up with demand. In Norway, the focus is on two species of kelp: *Saccharina latissima* and *Alaria esculenta* both of which are successfully being cultivated at several small farms along the Norwegian coast. For these species to become mainstream food ingredients, there are several challenges which must be solved, including scaling of sea farms and sea operations, definition of the ideal processing forms (e.g. freezing, drying, blanching or fermentation) and quality issues including contents of unwanted compounds (iodine, arsenic and allergens) as well as stability in product properties (dry matter, chemical composition, texture and taste). This contribution gives an overview of the present and near-future issues for offshore-farmed kelp in Norway both from a production perspective and in the light of market uncertainties. Final product types and the present status of the sector's development are discussed.

Abstracts

Assessment of a biorefinery methodology to produce high-value products from local harvested red macroalgae

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Biorefinery is an integrated system that efficiently converts biomass, through physical, chemical, biochemical, and thermochemical procedures into various products. This strategy applied to macroalgae allows to obtain bioactive extracts, bioethanol, lipids, polysaccharides, phycobiliproteins and fertilizers. The usefulness of the bioactive extracts includes nutraceuticals, antibacterial and antifungal products. The implementation of various extraction techniques in a biorefinery strategy, analogous to the oil industry, tends to increase the economic potential of these bioresources, reducing the production of residues or waste, valuing them, or using them as value-added and marketable by-products. Three local marine red macroalgae were used to produce several protein extracts, using phosphate buffer (0,1M, pH 6.8) and a pressurized liquid extractor. Phycoerythrin, a valuable bioactive pigment, was assessed in the protein extracts and higher values were from *Grateloupia lanceola* (3.11 mg/g dw), followed by *Nemalion elminthoides* (2.78 mg/g dw) and *Asparagopsis taxiformis* (0.29 mg/g dw). The extract optimization was performed applying a Box-Behnken design, varying two independent variables, sample weight (100, 200 and 400g fw) and number of cycles (6, 12 and 18). After protein purification, a liquid and solid residue will be assessed as a biostimulant and biofertilizer to evaluate its use in sustainable food production, through tests, where the “Cherry” variety of tomato will be used as a plant model. Reducing the use of synthetic fertilizers and pesticides, promotes crop protection against climate change drivers, such as drought, dilapidation of nutrients and increase of biotic stress, allowing to reach targets of the European Ecological Pact

Freezing and thawing methods to preserve the qualities of *Ulva fenestrata* as a food product.

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Kelp products have challenges related to production (epiphytes, short harvest period) and food safety (iodine, arsenic). The Norwegian industry is therefore looking at other species and fresh sea lettuce presented to the restaurant market generated great interest. However, restrictions are associated with the sale of fresh seafood (limited shelf life) and conservation methods need to ensure high-quality product delivered year-round. Little information is available about the effect of freezing on the quality of sea lettuce in relation to food safety, nutritional content and sensory characteristics. *U. fenestrata* grown under standard culture conditions were frozen under different methods and thawed with two different methods (room temperature vs. refrigerator) after 1, 5 and 10 months of frozen storage. Appearance, smell and flavor were evaluated and the combination of the two freezing methods (blast vs. normal) and thawing methods did not results any significant differences. Each sample was analyzed for fluid loss, dry matter, nutrient and microbiological contents. No coliform, mold or yeast had been detected. Drip loss was around 5 to 6%. Dry matter and nutritional contents were similar between treatments and the literature on *Ulva* species. Iodine (32 $mg.kg^{-1}$) and arsenic (< 3 $mg.kg^{-1}$), including inorganic arsenic (< 0.06 $mg.kg^{-1}$) were similar between treatments and much lower than those reported in kelp. Temperature registration provided a basis for calculating thermal conductivity, capacity and energy consumption. The energy´ s costs (freezing process and frozen storage) for 10 months was estimated at 10 Euro t^{-1}

Abstracts

The identification of potential food safety hazards for the processed seaweed for human consumption.

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In 2019 globally there was over 36 recalls/import alerts for the food safety hazards in seaweed based foods worldwide. Australia instigated 14 of the 36 recalls/alerts as these food safety hazards alerts/recalls were due to imported seaweed food products.

Australia is a net importer of seaweed. Annual imports to Australia in 2017/18 approached AUD $40 million, of which 85% was for human consumption. Currently there are a small number of Australian seaweed processors of food products, either as bulk wholesale ingredients or finished retail ready products in Australia, using line grown or collected wild seaweeds.

It is a requirement that all Australian food producers must meet section 3.2.1 (Food Safety Programs) of the Australian Food Standards Code as a minimum but most local food safety authorities have little to no understanding of seaweed food safety hazards & so do not inspect the premises, as a food processing site. All current worldwide "Seaweed Certification programs" only cover environmental sustainability & social responsibility within the wild harvest and farming of seaweeds/algae. None of the available standards cover any aspect of food safety hazard identification or control for the production of seaweed-based food products.

This session will look at some of the known food safety hazards within processed seaweed worldwide for human food consumption, with a focus on 2 Australian case studies: land pond grown sea lettuce & wild harvested golden kelp.

Abstracts

Blue Carbon Science for Indigenous Sovereignty: A Diasporic Kanaka ʻŌiwi Methodology

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Explicit research methodologies are essential for addressing the standpoint-derived obligations researchers have to local and Indigenous peoples, communities, and environments, yet they remain uncommon in the geosciences. As a diasporic kanaka ʻōiwi (Native Hawaiian, lit. person of the bone) environmental scientist and outsider on Indigenous Ainu land, I investigate my own kūlana (position, station)-derived kuleana (rights, responsibilities) as a case study. The foundational framework and theoretical lens for this research methodology are based in kānaka ʻōiwi scholarship. Specifically, I use an ʻupena of pilina (fishing net of social-ecological relationships) worldview, my moʻokūʻauhau (genealogies), and ʻōlelo Hawaiʻi (Hawaiian language) concepts and values. The general components of a research standpoint (epistemology, ontology, axiology, and social position) are thereby articulated through my moʻokūʻauhau-based kūlana. Derived from this process, my kuleana is to ensure knowledge produced by my research on macroalgal Blue Carbon sequestration potential advances decolonization and Indigenous sovereignty, particularly for kānaka ʻōiwi and Ainu people. In re-centering the focus towards holistic pilina (relations) with ʻāina (land and waters, lit. that which sustains), this framing also forces a shift away from the transactional nature of carbon offsets and ecosystem services accounting. Conventional research operates within and upholds existing settler systems of oppression and therefore, researchers must seriously investigate what role they can have in advancing justice, even through so-called basic science. While conducting conscientious research within this ethically-compromised system is complex and inherently flawed, this methodology may provide some guidance for other researchers to engage with their own kūlana-derived kuleana.

Abstracts

In discussion: outcomes and experiences of a collaborative Aboriginal seaweed workshop in south-eastern Victoria

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Wadawurrung Aboriginal people* have a long-standing and intimate relationship with their traditional lands and waters. This relationship has enabled the development of an in-depth and rich knowledge of local resources, including local seaweed species. The continuation of such knowledge within Aboriginal communities has been greatly impacted by the historical and ongoing effects of colonisation in Australia. Racist policies around land removal, the removal of children and the illegality of language and culture have led to much traditional knowledge on seaweed becoming fractured with communities, with different pieces of knowledge held by different community members, and other pieces potentially lost altogether. Aunty Judy Dalton-Walsh is a Wadawurrung Elder and seaweed knowledge holder, and will be presenting in conversation with her collaborator Zoë Brittain from Deakin University. They will be discussing her experiences of collaboratively organising and running a seaweed knowledge workshop for Wadawurrung community members, utilizing resources and expertise from Deakin Seaweed Lab.

*Wadawurrung lands can be found on what is now known as south and south west Victoria, Australia.

Developing cultivation protocols for two red Alaskan seaweeds with cultural relevance

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Wild seaweed harvest supports food security for Indigenous cultures. In Southeast Alaska, seaweeds feature prominently in Indigenous life through cultural practice and the social activity of gathering, preparing, preserving, and sharing. New concerns about the loss of wild biomass have prompted interest in developing cultivation methods for red ribbon (*Devaleraea mollis*) and stiff red ribbon (*Palmaria hecatensis*) seaweeds as an approach to supplement wild harvesting. Red ribbon (known as Pacific dulse outside of Alaska) is already grown at commercial scales in other Pacific Northwest states. However, the cultivation protocols described are not suitable for Alaska's ecotypes and environmental conditions. And there are no cultivation protocols for stiff red ribbon. Our goal is to develop indoor land-based cultivation protocols for year-round vegetative growth for both species, such that high-quality biomass can be harvested at regular intervals. We describe two potential cultivation approaches to grow both species in a land-based tumble culture system and present progress on determining optimal growing conditions and methods to reduce contamination. We also describe steps to bring cultures to open water as tumble cultures may be financially prohibitive for some communities in coastal Alaska. Mastering cultivation on land will lead to new possibilities to use Alaska's expansive, accessible coastline for future open water mariculture of these two species.

Abstracts

Integrating Macro-Algae Culture into Alaska's Salmon Aquaculture: A Resource for Aquaculture Organizations, the environment and a unique teaching tool for students in Southeast Alaska

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Harvesting salmon and other food from the ocean is an integral part of the culture and economy in the State of Alaska. A large contributor to the state's commercial salmon harvest is its Private Non-Profit (PNP) salmon hatcheries. This program started in response to historically low salmon abundance in the early 1970s and now contributes nearly 1/3 of commercially caught salmon, with 30 hatcheries releasing 1.7 billion salmon each year. These fish are reared each spring in ocean net-pens for a few months before their release, providing the space, nutrients, and infrastructure to integrate lower trophic level species such as seaweed. For the last three winters students and faculty from the University of Alaska Southeast have outplanted Sugar kelp (*Saccharina latissima)* and Ribbon kelp (*Alaria marginata*) near rearing chum (*Oncorhynchus keta*) and pink (*Oncorhynchus gorbuscha*) salmon in order to help determine the feasibility and measurable benefits of this form of Integrated Multi-Trophic Aquaculture (IMTA). Kelp growth, nitrite, nitrate, ammonia and dissolved phosphorous as well as dissolved oxygen and salinity are measured bi-weekly. As part of this work students not only learn about kelp ecology and sustainable aquaculture but they also gain skills using oceanographic equipment, operate small vessels and work closely with industry professionals. Future work will support aquaculture workforce development, increase the sustainability of salmon enhancement aquaculture in Alaska, improve food security and provide industry with a proof of concept important for demonstrating the potential economic and environmental benefits for IMTA in Alaska.

Abstracts

Iron limitation of kelp growth may prevent ocean afforestation

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Ocean afforestation (OA_F) has been proposed as a nature-based intervention for carbon dioxide (CO_2) removal whereby kelps are grown in oceanic waters to mitigate the effects of increasing atmospheric CO_2 concentrations. Currently overlooked in the OA_F debate are the vanishingly low concentrations of dissolved iron (dFe) which limits phytoplankton growth in the majority of the open ocean. In this study, we determined the limiting dFe concentrations for key physiological functions of a coastal kelp species, *Macrocystis pyrifera*, considered a promising candidate for OA_F. dFe concentrations of 0.007-10 µM limited *M. pyrifera* growth, resulting in poor health and mortality of this species. The cumulative effects of impaired physiological functions – growth, photosynthesis, respiration, pigment content and nitrate storage – drove the observed tissue lysis. These results indicate that healthy kelp growth cannot be sustained by open ocean dFe concentrations (0.1-0.6 nM). Further to this, limiting dFe concentrations resulted in the release of dissolved organic carbon (DOC) (0.43-1.56 µmol C gDW^{-1} h^{-1}) potentially causing shifts in the microbial community ecology offshore through stimulation or inhibition of the micro-heterotrophic population. Previously, nitrogen has been considered the key limiting nutrient for seaweed growth in the ocean, however our findings suggest dFe is the limiting nutrient for seaweed primary production beyond nearshore waters, likely restricting the habitat of *M. pyrifera* to coastal zones. Our study questions the viability of proposed OA_F and warns of potential ramifications to offshore marine food webs.

Land-based *cultivation of Codium* tomentosum and *Palmaria palmata*, in Portugal

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Over the last decade, ALGAplus Ltd. has been cultivating organic certified Atlantic seaweed, in a land-based IMTA system. Using nutrient-rich effluent from its own organic farming operation of European seabream and seabass, ALGAplus produces Atlantic seaweed species in a free-floating tank|raceway cultivation system for the global food and cosmetic markets. Pioneer in Europe, we settle our industrial development on research, with several partnerships and project participations.

In 2013 and 2014, the company started cultivation trials of *Codium tomentosum* and *Palmaria palmata*, developing its own vegetative free-floating production protocols of these species. These include a nursery phase, under controlled temperature and light conditions, and an outdoor phase in tanks up to 20. With a current annual maximal production of 0.6t (fw) *for Codium* and 1.1 t (fw) for *Palmaria,* 2023 goals are 2t- and 3-t, respectively.

The future strategy for optimization of OPEX and yield increase for *C. tomentosum* follows through sexual reproduction protocols, as well as the viability of long line/net floating structures in earthen ponds; this is currently ongoing in the Aquavitae project. For *P. palmata,* the limiting development factor for year-round commercial-scale cultivation at ALGAplus (PT) has been the water temperature in warmer months. The project Sølkelp is tackling this issue by testing our land-based cultivation protocols in Norway, through a partnership with Seaweed Solutions AS. With these steps, the company expects to take the lead in providing the EU market with sustainably farmed organic certified *Palmaria* and *Codium* biomass.

Macroalgae cultivation: impacts of mixotrophy, from strain selection to pilot scale cultures

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Productivity intensification of microalgal biomasses has been studied for a few decades, heterotrophy or mixotrophy are serious options to promote specific metabolic pathways (1). To our knowledge there is no record of heterotrophic or mixotrophic cultivation of macroalgae. Our previous work showed that host-microbiota balance is a key factor to keep macroalgae in good conditions (2). We also demonstrated that it is possible to screen strains able to grow under mixotrophy with their microbiota (3). Two of these non-axenic macroalgae were selected to assess culture scale-up feasibility in the presence of organic carbon.

A green and a red macroalgae were grown under autotrophic and mixotrophic conditions in 300L airlift photobioreactors in a modified Provasoli medium under continuous light at 20°C for 14 days. Addition of organic carbon in the mixotrophic culture was the sole diverging condition from the autotrophic culture. Cultures were reproduced to assess process robustness.

Mixotrophy led to an increase of productivity of 50 to 70% depending on the tested strain and had an impact on suspensions morphology and their physical properties.

Water extracts of mixotrophic and autotrophic biomasses were analysed through High Pressure Liquid Chromatography (HPLC) coupled with a Diode Array Detector (DAD). Results showed their phytochemical content was notably different in terms of quality and quantity.

Underlying mechanisms managing microbiota-algae interaction in the presence of additional organic carbon sources are still to be investigated to optimize this new way of biomass production.

Scale-up feasibility, increase of productivity and phytochemical content differentiation makes this proof of concept a success to produce innovative cosmetic active ingredients.

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Abstracts

Developing hatchery-based reproduction methods for year-round production of *Palmaria palmata* in the North Atlantic

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Seaweed cultivation is crucial in developing low-carbon alternatives to agriculture and support the transition to a sustainable bioeconomy based on marine natural resources. The red seaweed *Palmaria palmata* (dulse) occurs naturally throughout the northern Atlantic and is traditionally harvested and consumed as foodstuff. Market demands are increasing, and the supply is not readily available due to various factors, including naturally fluctuating quality products and seasonality. Facing an increase in demand, it is a prime candidate for the development of sustainable cultivation methods. Reproduction seasonality is an issue in securing year-round supplies. Our research aims to develop protocols for controlled reproduction and vegetative growth of seedlings in hatchery setting to maintain continuous cultivation cycles. The possibility that different strains in the different geographic areas might have different needs to secure a year-round available product was tested. The reproduction and growth of local phenotypic identity populations from Norway and Faroe Islands at different temperatures (5 and 10 °C) were followed for 6-8 weeks, using 3 growth media (VS, F/2 and seawater (as control)), light intensity of 20 ± 1μmol m^{-2} s^{-1} (8:16 hours light/darkness). Spore lengths were compared using image analysis and results indicate that the temperature of 5°C promoted the best growth of seedlings, both in VS and F/2 for the two populations. Both reproduction and vegetative growth of seedlings are promising approaches that can be implemented for year-round production of *P. palmata* in the North Atlantic.

Screening of seaweed species for cultivation associated with land-based aquaculture.

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Fish-farms produce as by-products nutrients–nitrogen and phosphorus–that can be used by seaweeds to grow and, consequently, produce biomass that can be valorised in different applications. We aim to find specific seaweeds to grow in a fish farm effluent that has specific traits such as low salinity (~23%), moderate temperature (~19ºC), high and low levels of nitrates and ammonium, respectively. The seaweed species selected for this experiment were *Chondrus crispus, Gracilaria multipartita, Mastocarpus stellatus, Osmundea pinnatifida, Porphyra sp. and Ulva sp*. Seaweeds from North Coast of Portugal were collected, acclimated for seven days and exposed to this effluent for three weeks under the following conditions: 5 g L^{-1} of density, 19ºC of temperature, 23% of salinity, 150 µmol photons m^{-2} s^{-1} and a neutral photoperiod of 12h:12h (L:D). Part of the effluent was adjusted to 33% salinity to determine whether salinity was a limiting factor. Every week the effluent was exchanged and water samples were collected for nutrient uptake, pulse- amplitude modulation (PAM) for photosynthetic activity and fresh weight for relative growth rate (RGR). *Gracilaria multipartita* was affected by salinity. The adjustment of salinity to 33% allowed to reach higher growth rates (22%:3.76±1.34 % day^{-1}, 33%:5.67±1.54 % day^{-1}). The remaining seaweeds were not affected by salinity. The seaweeds that showed best growth rates on the original effluent were *G. multipartita* (3.76±1.34 % day^{-1}), *O. pinnatifida* (2.09±0.72 % day^{-1}), *Ulva* sp. (1.59±1.14 % day^{-1}), **C. crispus** (1.33±0.86 % day^{-1}) and *M. stellatus* (0.88±0.46 % day^{-1}). The best performing seaweed will be grown in a pilot scale seaweed cultivation system associated with the fish farm to assess productivity at real-life conditions.

Targeting commercial scale production of Atlantic Nori conchocelis

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ALGAplus Ltd. is the European pioneer farming year-round organic certified Atlantic Nori species (*Porphyra umbilicalis* and *P. dioica*), for food and cosmetic markets, using a sustainable IMTA system. Our biobank holds around 30 *Porphyra* spp. strains since 2014, and counting, since novel strains from Northern Portugal populations are being collected to increase the genetic pool for future characterization, selection and improvement of market value. The genetic validation of all Atlantic Nori strains in production has been performed and is an ongoing work in partnership with GreenCoLab.

The commercial production of conchocelis holds potential as a new ingredient for the food, nutraceutical and cosmetics sector; and providing "seed" for emerging Atlantic Nori farmers. When compared to blade production, conchocelis have a shorter production cycle, manipulation is easier and they are less exposed to variable abiotic factors. Additionally, targeted enriched biomass can be achieved in controlled conditions, as pigments and lipids for distinct applications, which will be validated in the framework of the project Algaesolutions (PT 2020).

Up to now, the conchocelis production at ALGAplus surpasses the capacity of blade production, creating an opportunity to use the excessive conchocelis biomass as a final product. The company has validated the industrial production and market acceptability of conchocelis in indoor photobioreactors, yielding a daily average growth of 0.64 $g.l^{-1}$ corresponding to 7% (RGR). This year, we expect to produce 300kg *fw* with a potential to increase depending on market demand.

Abstracts

Comparison of farming and drying methods of seaweed and factors affecting its growth in Fiji.

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This paper presents the findings of research based on seaweed farming carried out at Galoa Island, Kadavu, Fiji. The general objective of the study was to compare two farming methods and two drying methods for the seaweed *Kappaphycus alvarezii* in Fiji. The study has five specific objectives which was to: (1) collate and synthesize the history of seaweed production in Fiji, with a focus on *K. alvarezii,* in order to develop a strategy for the research components; (2) to assess and evaluate the *in-situ* growth rates of *K. alvarezii* using two different farming methods; (3) to assess and evaluate the effectiveness of two different drying methods; (4) to test the *ex-situ* growth rates of *K. alvarezii* under a range of controlled salinity and temperature levels and (5) to assess the importance of seaweed farming in the community using surveys and key informant interviews.

The field trials were conducted whereby the two different methods of seaweed farming "off bottom" and "floating longline", were applied with the two different drying methods, "hang dry" and "dry on rack". Laboratory experiment was also carried out where the seaweed was grown in a more controlled condition of salinity and water temperature. Socio-economic surveys were also conducted via targeted key informant interviews conducted in the seaweed farming associated community.

The study found that the percentage weight change for both methods did not vary significantly indicating that neither method is superior however the cold season May to October as the best season to cultivate *K. alvarezii* in Fiji. The best salinity to cultivate *K. alvarezii* is 31psu with the water temperature of 29 ˚ C. With the two drying methods, it was clear from the laboratory experiments that there was no significant difference between the two methods in terms of the reduction of moisture. The analysis with the experiment carried out in the laboratory pointed out that the best temperature to use under the controlled environment is 29˚ C with the salinity of 31 psu. *Ice-ice* was a common disease that affected the growth of *k. alvarezii* and this was a result of stress, which was caused by non-optimal in both salinity and temperature.

Seaweed farming that is an alternative sustainable livelihood and a potential source of income to the villagers can be used as a value adding commodity even before it reaches it markets. There is no barrier from being involved in seaweed farming activities but undertaking farming requires a lot of sacrifice and commitment and hard work because of the different stages involved are labor intensive and require development of skills and experience. Although farming can be carried out individually, the involvement of groups is recommended, as this will boost the end production. The Ministry of Fisheries operational plan promotes seaweed farming in coastal villages as a strategy to reduce terrestrial degradation via crop production (Ministry of Fisheries Fiji Strategic Plan 2019-2029). The unpredictable weather conditions in Fiji, both now and into the future, are a threat to seaweed farming especially with Kadavu being a regular cyclone track and this has caused a lot of devastation for seaweed farming in the past.

Abstracts

Engaging communities, grassroots activism, and the fight to save our giant kelp.

Peter Whish-Wilson

Senator for Tasmania

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In the second half of 2021, Senator Peter Whish-Wilson embarked on a state-wide film tour of lutruwita/Tasmania, with the purpose of engaging the community and raising awareness of the dire plight and environmental challenges faced by Tasmania's giant kelp forests.

Touring the film "Tasmania's Troubled Waters" – a documentary produced by Peter's Senate office, the tour went around the state "Town Hall style" in a specifically designed, depoliticised format focused entirely on discussing the issues faced by our giant kelp forests.

The format of the events included a screening of the documentary, followed by comments from special guests that included marine scientists, fishers, environmental restoration workers and members of the Tasmanian Aboriginal community. A Q&A was also facilitated to ensure community was included in the discussions.

In this presentation, Peter will share snippets of his documentary and outline the insights he has gained from his work engaging with Tasmanian communities on this issue and the important role that community engagement and activism plays in the fight to protect Australia's giant kelp forests.

Peter Whish-Wilson is a Greens Senator for lutruwita/Tasmania, and the Australian Greens Spokesperson for Healthy Oceans, Agriculture and Waste.

An economist, activist and surfer, Pete is a passionate advocate for our marine environment and continues to use his platform to communicate the importance of restoring and protecting the giant kelp forests of lutruwita/Tasmania and Australia.

Abstracts

First restoration experiment for endemic *Fucus virsoides* on western Istrian coast

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Fucus virsoides J.Agardh is an endemic species of intertidal, canopy forming algae and is the equivalent of the much larger „Bladderwracks"of the Atlantic and Pacific coasts. While very abundant even in the recent past, especially in the northern Adriatic, nowadays the species can be considered ecologically extinct. We have developed a very simple, but seemingly effective method for *ex situ* cultivation, which is very useful for restoring lost, and the enhancement of remnant populations. *F. virsoides* recruits were grown from receptacles collected from a small donor population and were used to seed 10x10 and 5x5 cm stones with propagules in aquaria. The survival and growth of the recruits were monitored, and fouling was regularly controlled. The cultivated recruits were later relocated from aquaria with controlled conditions to outdoor stone basins with constant exchange of natural seawater. Finally, after reaching the height of about 1cm, they were planted at two locations in Rovinj area (northern Adriatic), where the species has disappeared in the last 10 years. The morphological measurements so far indicate that the planted *F. virsoides* specimens are thriving and growing over 10 cm in height in ten months as well as showing signs of fertility. Furthermore, seawater temperature at the microlocality was measured during 2022. While we have proven that it is entirely possible to cultivate *F. virsoides ex situ,* it remains to be seen whether the planted patches can cope with the increasingly occurring heatwaves and whether they are able to self-disperse to form a new small population.

Abstracts

Harnessing the power of citizen science to advance kelp farming in Alaska

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In 2018, Alaska published a dynamic and comprehensive plan to boost shellfish farming and establish a viable and sustainable kelp mariculture industry, leading to long-term benefits for the State's economy, environment, and communities. Kelp production has increased substantially since 2017, when commercial kelp was first harvested. Kelp farm sites in Alaska are selected based on proximity to compatible supply chains, boat ramps, or ports, with a preference for areas offering protection from wind and waves. Although these criteria for site selection are essential, they overlook kelp biological requirements. Likewise, harvest timing follows standard practices without considering how the nutritional quality and or other chemical properties of kelp may vary as a function of species or site. Harnessing the power of citizen science has proven an effective approach to addressing site selection and harvest timing that is responsive to Alaska's extensive and environmentally diverse coastline. Farmers and researchers have teamed up to collect biological and environmental data from 16 southcentral and southeast Alaska farm sites. Here I will describe some particular challenges in site selection, present data showing the need to address site selection on a case-by-case basis, and share some insights on the importance of monitoring farm site environmental conditions to determine ideal harvest periods.

Abstracts

Habitat provisioning by a UK seaweed farm

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Seaweed farms are expanding rapidly in Europe, in response to increasing demand for seaweed-derived products for human food, cosmetics, agriculture and industry. Seaweed farming may offer additional ecosystem services, such as habitat provisioning and elevated local biodiversity, which could benefit other marine industries including fisheries by providing breeding or feeding grounds to fish species. The habitat value of seaweed farms has largely remained unquantified, however, with most research focusing on mitigating detrimental biofouling, rather than highlighting the potential contributions of farm-associated biodiversity to healthy ecosystem functioning. We monitored the development and diversity of epibiont assemblages on sugar kelp (*Saccharina latissima)* from a farm in southwest UK and compared these assemblages to those found on wild kelps. We found significant increases in epibiont abundance and diversity on farmed kelps over and beyond their growing season, reaching an average of 6196.3 ± 450.4 SE individuals per kelp and 9.7 ± 0.17 SE taxa present by August 2020. Assemblages on farmed kelps were dominated by amphipods, bivalves and bryozoans, which are detrimental to crop quality, yet contribute to bioremediation and provisioning of food for higher trophic levels, such as commercial fish species recorded at the farm. Wild kelps hosted significantly fewer epibionts (87.2 ± 56.0 SE), but had a higher taxonomic richness (13.3 ± 0.42 SE), suggesting seaweed farms may offer novel habitats in coastal areas. Increased understanding of epibiont assemblage development could improve the habitat value of seaweed farms, while optimising crop yield for farmers as an example of sustainable ecosystem-based aquaculture.

Photo elicitation as a method to investigate the seaweed value chain in Samoa

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In Samoa, there is an opportunity to transform seaweed fisheries as a gender inclusive, nutrition-sensitive food system to improve environmental and livelihood outcomes for local communities. Photo-elicitation is a qualitative technique, whereby images are used as a reference point to frame responses during focus group discussions. The aim of this study was to engage with men and women in coastal communities of Samoa using a photo elicitation approach, to explore their current and potential role in local seaweed food supply and value chains. The study was set in ten coastal communities of Samoa, on the island Savai'i. Focus group discussions (n=20) were conducted with a total of 135 participants. Findings highlighted the need for overall governance of seaweed at the village level (including planning and management), with an emphasis on sustainable farming and harvesting practices. Governance of seaweed (as a collective resource) was perceived to occur within existing social village structures (Fa'amatai system), which may present barriers for women in terms of equal involvement in village decision making, access to the reef and other opportunities. However, there appears to be a desire to work better together from both men and women. This approach engaged local people as active participants in the research process, which has guided the development of a subsequent capacity building programme. The programme is being used to support men and women, in agreement, to establish sustainable food supply chains at the village level, thus providing reliable access to fresh food and income and improving health and livelihoods.

Abstracts

Seaweed cultivation for nutrient management to supplement to nutrient removal processes in wastewater treatment

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Though advanced wastewater nutrient removal processes in coastal water resource recovery facilities (WRRFs) can reduce nutrient inputs and mitigate marine eutrophication, they significantly increase economic and environmental costs, especially in small facilities. This study investigated the potential of using bioextractive macroalgae aquaculture (*Saccharina latissima* and *Gracilaria tikvahiae* cultivation) from economic and environmental perspectives to trade nutrients discharged from WRRF as an alternative or supplement to advanced wastewater treatment processes towards achievement of three levels of nutrient effluent goals (level 1: 8.0 N-mg/L and 1.0-P-mg/L; level 2: 3.0 N-mg/L and 0.1-P-mg/L; level 3: 1.0 N-mg/L and 0.01-P-mg/L). WRRFs ranging in size from 379 to 18 927 m^3/d (0.1 to 5.0 MGD) were investigated using several (scale-appropriate) physical, chemical, and biotechnology options for nutrient management. Seaweed cultivation systems investigated included single and dual layer longlines and cultivation strips. Dual layer strip platforms (DLS) could reduce aquaculture size requirements by 44% over single layer longline platforms (SLL) with economic and environmental advantages. Compared to WRRF only scenarios, mixed scenarios of WRRF and bioextractive aquaculture reduced the net cost of nutrient removal by \$0.71 to \$5.37 per m^3 of wastewater treated. Mixed scenarios are also associated with overall reduced environmental impacts. Net environmental benefits were observed in marine and freshwater eutrophication and human noncarcinogenic toxicity.

Abstracts

Carbon sequestration by macroalgae: challenges and opportunities

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Macroalgae are increasingly under consideration as a nature-based climate mitigation strategy, attracting interest from a range of policy, industrial, and conservation actors. Additionally, several countries have indicated an interest in including wild macroalgae conservation and/or macroalgae farming in their Nationally Determined Contributions (NDCs) under the UN Framework Convention on Climate Change (UNFCCC). Several uncertainties remain, however, around whether sufficient scientific knowledge is available for macroalgae carbon to be included in climate policy actions and related financial mechanisms. This talk will provide an overview of some of the knowledge gaps precluding macroalgae integration into existing accounting frameworks, and discuss some of the opportunities that the uniqueness of macroalgae carbon sequestration may bring. The talk will also provide an introduction to the mini-symposium *Carbon cycling and sequestration by macroalgae*

Abstracts

Global and regional variation in seaweed export to potential carbon sinks

Karen Filbee-Dexter[1,2], Albert Pessarrodona[2], Jorge Assis[3], Trine Bekkby[4], Michael T. Burrows[5], Carlos M. Duarte[6], Jean-Pierre Gattuso[7], Hege Gunderson[4], Kasper Hancke[4], Dorte Krause-Jensen[8], Kira A. Krumhansl[9], Jack J. Middleburg[10], Pippa J. Moore[11], Sarah B. Ørberg[8], Morten F Pedersen[12], Isabel S. Pinto[13], Ana M. Queirós[14], Ester A. Serrão[3], Dan A. Smale[15], Thomas Wernberg[1,2]

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The world's seaweed forests are the largest vegetated ecosystem in the ocean with productivity rates comparable to phytoplankton. Yet, the fate of the large flux of carbon exported from seaweed habitats is a key unknown in the oceanic carbon budget and prevents accurate estimates of seaweed blue carbon potential. Here we create the first spatially explicit global estimate of seaweed carbon export to the open ocean by combining global models of seaweed forest distribution and net primary production (NPP), with seaweed decomposition rates and oceanographic models of coast-ocean exchange. Export potential of seaweeds across the shelf break (>200 m depth) was on average 10.6% of annual NPP or 27.9 g C m^{-2} y^{-1}, which equates to 47.5 Tg C per year globally. National estimates show that some regions have high fluxes of seaweed carbon to the open ocean, likely due to a combination of narrow continental shelves, submarine canyons and unique oceanographic features, as well as large total seaweed NPP. Significant detrital seaweed carbon crosses the continental shelf near the meso-bathypelagic boundary, suggesting this carbon can reach deep ocean zones of long-term storage and slow rates of surface exchange. These findings demonstrate high spatial variability in seaweed fluxes to deep ocean areas adjacent to the coastal zone, which has consequences for energy inputs to mesopelagic ecosystems and estimates of overall carbon sink potential of seaweed forests.

Abstracts

Developing tools and processes to measure, report, and verify carbon uptake, deposition, and sequestration rates on seaweed farms

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Sequestration of carbon dioxide (CO_2) captured from the atmosphere is recognized by the International Panel on Climate Change as a fundamental requirement to limit global warming below 2°C by 2100. Metabarcoding and stable isotope data have revealed that traces of seaweeds can be found in deep, offshore marine sediments. As a consequence, it is proposed that farmed seaweeds may contribute to a blue carbon climate mitigation solution. Fragments of farmed seaweed biomass fall from the subsurface farms as detritus or sloughed particulates during the growth phase and also as culled holdfasts and biofouled blades during harvest. A portion of this discarded seaweed biomass may be buried in marine sediments where it would essentially be removed from the global carbon cycle. However, peer-approved methods for quantifying and verifying whether and how much carbon is captured and subsequently shed during these standard farming operations, and how much becomes transported, remineralized, or buried in the benthic sediment, do not yet exist. We review customized oceanographic sensor technology to quantify inorganic and organic carbon fluxes and species-specific DNA-based quantitative tools to attribute carbon flux to farmed sugar kelp (*Saccharina latissima*). We present preliminary data for inorganic carbon uptake and organic carbon deposition rates measured at sugar kelp farms in coastal Maine, USA, and discuss the limitations and advantages of various approaches. Tools and protocols such as these will be critical to providing realistic and robust sequestration rate estimates, and to allow seaweed famers to capitalize on carbon offsets and volunteer markets.

Addressing key gaps hampering incorporation of kelp carbon in policy and finance frameworks

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International climate policy frameworks are a major influence on which climate mitigation activities are widely adopted. These frameworks currently incorporate coastal 'blue' carbon, in a way that is based on adaptations of methods originally developed for land use change and forestry. The methods are based on storage and sequestration of organic carbon in soils where activities occur, and so are not well suited to kelp carbon, for which most sequestration happens in areas distant from kelp forests. Development of blue carbon markets has also largely been based on adaptations of mechanisms developed for land use change and forestry, and so are similarly ill-equipped to incorporate carbon from kelp forests. Voluntary carbon market methods can be early adopters of new approaches, and do not necessarily need to be constrained by international climate policy frameworks. However, carbon units traded in high integrity markets do require adherence to stringent requirements regarding permanence and additionality. These in turn require a sound understanding of the fate of organic carbon. These processes have not yet been well resolved for kelp-derived carbon. We discuss the information requirements associated with international climate frameworks and carbon markets, highlight some of the key similarities and differences between kelp forests and other vegetated ecosystems, and explore the key knowledge gaps that need to be resolved to incorporate kelp blue carbon in policy and finance frameworks.

Abstracts

A critical review of life cycle climate impact in seaweed value-chains to support carbon accounting

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Seaweed is often touted as a blue economy resource with climate benefits. Several calls are made to scale the industry up and to use blue carbon financing to create additional incentives for the sector to expand. But how much of a climate crisis panacea is seaweed, and under which conditions can climate benefits be realized? The article reviews the literature on climate impacts from seaweed value chains and proposes a cradle-to-grave structure for carbon accounting in seaweed value chains. While the literature points towards several ways in which climate benefits can be generated, the evidence base for net negative emissions across the value chain is not robust enough to suggest seaweed value chains, by default, are a climate solution. Instead, climate effects depend on the specific production setup, product choice and the fate of the product on the market. Climate benefits can only be claimed by tracking blue carbon flows across whole life cycles and over time. Knowledge gaps relate to effects at sea, the role of temporarily locking carbon into products and the effects of introducing this resource to the market. Blue carbon financing should be directed only to setups proven to lead to additional and permanent carbon storage.

Integration of precision technology into adaptive phyconomy systems for extensive tropical red seaweed farming

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Efforts are underway among phyconomists to blend precision techniques into the adaptive phyconomy systems that are prevalent in commercial seaweed farming. Phyconomy is the branch of applied phycology that comprises systems of art, science and technology applied to production systems that yield crops of algae. Adaptive phyconomy is a low-cost, low-control approach that is practiced in situations where the biology of algal crop organisms is poorly understood and/or where confounding variables render precision technologies impractical. Precision phyconomy, on the other hand, is a high-cost, high-control approach to algal crop production that is practiced in situations where the biology of crop organisms is well understood, and culture conditions can be comprehensively controlled. With respect to extensive ocean farming of seaweeds, adaptive phyconomy methods prevail, even as the science and technology sector aspires to apply precision techniques to commercial seaweed farming systems; especially in the cases of farm mechanization, information technology, biosecurity, tissue culture techniques and molecular taxonomy as applied to cultivar development and propagation. As phyconomy systems evolve, precision techniques will progressively displace adaptive approaches to yield extensive farm systems that are intermediate on the adaptation-to-precision heuristic model curve.

Precision products from Precision Phyconomy

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Precision products are products of consistent quality & consistent performance across various applications.

The manufacturing of any product from biological raw materials, like seaweed, involves several steps and the variable nature of such natural starting materials can cause variations in quality and performance of the end products. Control over the raw material properties and quality would help immensely in making consistent products. Precision phyconomy cultivation techniques, outlined elsewhere, are a key to the production of sustainable, consistent starting raw materials.

In addition to consistency, it is important to be able to identify and quantify the functional active ingredients in the products and their relative importance in the final product performance.

It is extremely important to develop a manufacturing process that enables these active ingredients to be extracted from the raw material with robustness at large scale within the constraints of a production unit. This involves identifying and setting the ranges of the process parameters that have an effect on the extraction or production of the active ingredient from the starting raw material.

Finally, analytical methods and bio-assays have to be developed that can be used to control the process and formulate the finished product from every batch to a standard specification so that a precise, controlled and consistent final products can be reliably and repeatably produced .

This presentation will outline how Sea6 implemented the above techniques to produce a range of precise, biostimulant and immunostimulant products for use in agriculture where all the above criteria have been met.

Land-based precision phyconomy – lessons to be learned from microalgal production.

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Seaweed aquaculture increased 74% from 2010-2020, totaling 35.1 million metric tons in 2020 (FAO, 2022). More than 99% of this amount is produced in the western Pacific and, still according to FAO, > 95% of the production is based on only five genera, *Saccharina/Laminaria*, *Undaria*, *Gracilaria*, *Neopyropia* and *Eucheuma/Kappaphycus*. These are mostly produced at sea (offshore or nearshore). Considering >10 000 species described, it is reasonable to assume there remain many species that, due size, morphology, robustness and other traits, are not suitable for open water aquaculture.

As new applications are being developed, based on "novel" species for aquaculture, new requirements/standards must also appear. Requirements such as strict quality control, both in terms of safety and chemical composition, can only be achieved using production techniques that allow for traceability and control of all the steps of the process. In parallel, just as is happening with the production practices of other foods or materials, the degree of scrutiny from the market is increasing, including in terms of environmental sustainability.

Land-based seaweed aquaculture is an answer to some of those "criteria" and allows for the domestication and exploitation of many new species provided their cultivation is profitable. Macroalgal aquaculture needs to evolve to the level of "precision phyconomy". Microalgal production is so far, more advanced in terms of system control, water re-utilization, artificial media development, precise use of nutrients, irradiance, amongst others.

This presentation discusses how on land seaweed cultivation can learn from the precision phyconomic practices of microalgal aquaculture.

Abstracts

Developing cultivation systems and best management practices for the precision phyconomy of Caribbean seaweeds in US waters

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The Caribbean's small countries and island nations are experiencing a loss of resources due to climate change, nutrient pollution, ocean acidification, seagrass bed habitat loss, fishing pressure, and lost tourism revenues due to COVID-19. We believe that well-managed development and growth of tropical seaweed aquaculture, using applications of precision phyconomy in the region, may help to assuage these issues whilst also providing a new source of seaweed biomass for the existing carrageenan, new food and textile, and possibly future biofuel markets. We are exploring the opportunities for expanded seaweed aquaculture in the Caribbean and the Gulf of Mexico in collaboration with partners across 15 institutions and research sites in Puerto Rico, Florida, and Belize. Together we are prototyping advanced, extensive cultivation systems and engineering that will allow future farms to be deployed in offshore areas. This also involves the important steps of creating tools to mechanize seeding and harvesting processes, as well as optimizing nursery conditions for seedstock, assessing the environmental footprint of these farm systems, characterizing the growth and composition of tropical algae in near and offshore environments, and conducting economic and life cycle analyses of these advanced phyconomic practices in this region. Findings from these efforts will be tailored to the conditions in the Caribbean and Gulf of Mexico but can be adapted for other locations with similar environmental conditions or needs for alternative marine livelihoods.

Abstracts

A Needs Assessment for Precision Phyconomy Development in Changing Climates

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Adaptive phyconomy is the art and science of growing seaweeds in coastal seas where seaweed farmers are at the mercy of "mother nature". Crop productivity and market dynamics are correlated with oceanographic, meteorological, and socioeconomic phenomena for which the current data base is almost negligible, and farm-based knowledge is mainly in the minds of farmers. All of this is taking place in a world where climate change is a phenomenon that is barely quantified in coastal waters. Seaweed farming must evolve beyond a predominantly adaptive approach. It must evolve toward precision phyconomy as seaweed farming fits into multi-biomass systems for ecosystem services management in coastal ecoscapes that are subject to climate change. We provide a brief wish-list of knowledge, information, tools, and solutions needs that are fundamental to precision phyconomy development. These needs are currently not being met but can be satisfied with due diligence applied to existing and evolving technologies.

Abstracts

Deepwater irrigation rescues production of tropical seaweeds year-round: ramifications for temperate kelp-forest regeneration

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Climate warming and marine heatwaves have raised epipelagic ocean temperatures and lowered nutrient levels associated with upwelling in [sub]tropical and seasonally temperate regions. This environmental disruption reduces the extent and growth of seaweeds underpinning marine ecosystems, e.g. (*Macrocystis pyrifera*) forests in Tasmania have declined by ~95%.

Renewable energy can be harnessed to restore natural upwelling by regenerative upwelling or deep-cycling of seaweeds accessing nutrients from the mesopelagic zone, reducing ocean stratification and primary production loss. Results from deep-cycling trials and regenerative upwelling show significant restoration of growth rates of multiple macroalgal species consistent with pre-industrial production rates. Measured monthly growth rates of 100-300% per month for red seaweeds and much higher growth for green seaweeds clearly demonstrate production increases under deepwater irrigation. Such approaches have reached fractional-hectare scale under field conditions offshore so that; production can extend across countries with marine EEZs and landlocked countries can apply these techniques in international waters.

Measurements of the significant percentage of seaweed falling off platforms during growth, sinking to the seafloor at rates >1000m/day. Ample physical oceanographic evidence shows that once the biomass reaches such depths it is sequestered for hundreds to thousands of years, even if remineralized into abyssal CO_2. Green seaweeds show particularly high potential. Deep-cycled pneumatocyst seaweeds sink rapidly, unlike their surface-irrigated counterparts.

Regenerating primary seaweed production at scale can address key needs for; Food security in a climate-disrupted world, marine ecosystem services including temperate kelp-forest regeneration, measurement of carbon export and long-term sequestration of carbon dioxide.

Abstracts

Developing sustainable seaweed aquaculture in New Zealand

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The native kelp *Ecklonia radiata* is a target for the emerging seaweed aquaculture industry in New Zealand, however, key knowledge regarding domestication and variability in biomass quality is still lacking. During my PhD, I have collected *E. radiata* samples from 12 sites within four regions around the North Island of New Zealand and analysed their genetic and biochemical composition. Using 13 microsatellite loci, I found that *E. radiata* shows strong genetic structure and low gene low both on local and regional scales and therefore recommend not to translocate cultivars of *E. radiata* outside their area of origin. Despite the strong genetic structure, no spatial patterns in biomass composition were found, and instead, an overall high content of commercially important components was found, including phlorotannins (6.6 ± 1.5 sd % dry weight), alginate (25.0 ± 2.4 sd % dry weight), and fucoidan (1.2 ± 0.1 sd % dry weight). Important components such as lipids, proteins, glucose, guluronic acid, nitrogen, phosphor and iodine showed significant seasonal fluctuations (measured by autocorrelation), underlining the need for timed harvest depending on the product of interest. Combining the biochemistry data with spectroscopy data, I constructed models for fast and easy determination of biomass quality for industrial purposes, and together these findings provide a foundation for developing sustainable aquaculture practices of *E. radiata*.

Abstracts

The feasibility of scalable coastal and offshore kelp mariculture in Alaska

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The mariculture of seaweeds is becoming increasingly popular in Alaska. With funds from the ARPA-E MARINER program, we tested different seaweed farm designs, seeding methods and harvest approaches for a scalable solution for the mariculture of *Saccharina latissima* (sugar kelp). Farm designs were based on catenary structures with or without the use of spreader bars with variable spacing of growlines. Initial results show that line spacing can be as short as 1 meter with no adverse effects on yield. There was no statistical difference in the growth of *Saccharina* whether in the middle or the outside of the array. Sagging caused by the weight of the mature fronds resulted in slower growth at depth. We have experimented with several "direct seeding" methods – spraying or painting both gametophytes and embryonic sporophytes on several different substrates, including the growlines. Some success was demonstrated with the outplanting of directly seeded growlines. Our cooperating farmers tested various approaches for harvesting mature kelps. One innovation that has worked well is the use of large bags for holding the freshly harvested fronds. Although the weight of the fronds on the growlines causes the lines to sink, the bags packed with the harvested fronds float, allowing for easy loading onto the transfer vessel. Another advance in harvesting is a specially built harvest vessel, the *Kelp Buddy*, which was in operation for our last two seasons. We also employed a large seiner that was modified for harvesting the growlines.

Abstracts

Challenges and opportunities for kelp aquaculture in Tasmania, Australia

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Brown seaweed species of the order Laminariales and Fucales (Phaeophyceae), are commonly known as the kelps, have substantial global economic and ecological importance. Kelp aquaculture has developed significantly in recent years, with a wide array of products already on the market, and new kelp-based products constantly in development. Whilst kelp aquaculture has historically been focused in Asia, it is emerging in "non-traditional" regions of production, including Tasmania, Australia. Being an island state with relatively clean coastal waters and a unique marine flora, Tasmania is well positioned for a thriving seaweed aquaculture industry. Building on early work and the latest findings I will discuss the challenges and opportunities for kelp aquaculture in the indoor hatchery phase as well as the at-sea cultivation in both the near and off-shore environment.

From the experimental to commercial cultivation: the establishment of a new seaweed farming in South Brazil

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Kappaphycus alvarezii was introduced on an experimental farm in Southern Brazil in 2008 to evaluate the viability of commercial cultivation in the region. During the experimental trials, two main bottlenecks for the production were identified: the low temperatures in the winter, and the drying process, since Santa Catarina has high rainfall index in some periods of the year. Despite that, the commercial and environmental viability was proven. In 2020, Santa Catarina State had permission to cultivate the species commercially after twelve years of studies and negotiation with the Brazilian Government. However, only in 2021 local producers get the license and start commercial production. Even though the previous social-economical studies focused on the carrageenan market, the central sector which showed interest and investment in biomass production was agriculture, focusing on biofertilizers. The first production cycle started in September 2021 and finished in April 2022. In this period, four licensed producers produced on their farms (total area of 3.20 ha) approximately 102.3 tons of seaweeds (wet weight). The price for the seaweed was higher than those for the carrageenan industry. Moreover, producers can process their seaweeds and directly deliver the liquid biofertilizer to the industry without depending on the drying process. Considering the 612 marine farms totalizing 1,346.90 ha that Santa Catarina State has, this new activity probably will bring new incomes to the traditional sea producers in the South of Brazil.

Abstracts

Area-based management framework for the ecologically sustainable development of seaweed aquaculture in South Australia

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South Australia's aquaculture industry generates 50% of the State's seafood economic output, worth $200 million in 2020/21. A rapidly emerging sector likely to expand the industry is seaweed farming. The State's legislative framework provides a one-stop-approach to the development, regulation and licensing of seaweed aquaculture. A fundamental feature is the capacity to establish dedicated aquaculture zones in State waters to promote the ecological sustainable development of the industry. These zones represent a unique marine spatial planning approach for access to a shared resource. Twelve aquaculture zone policies are prescribed in South Australia, nine of which currently permit seaweed farming. Case studies will outline the review of aquaculture zone policies to permit seaweed farming and foster the interest of local Aboriginal communities in aquaculture activities. The first seaweed aquaculture licence in South Australia was issued to the Narungga Nation Aboriginal Corporation.

Currently, South Australia has 50 aquaculture licences (marine and land-based) permitted to farm seaweed. The sector's full potential is yet to be realised and the risks associated with disease, inadvertently moving pests and causing genetic contamination of local populations, primarily through stock translocations, are not yet understood. South Australia has implemented Macroalgae Management Areas, with the aim to protect aquatic ecosystems and genetic diversity across the State's coastline - home to >1100 species of seaweed (many of which are endemic). Based on historical surveys, the management areas broadly represent key habitat distributions and therefore provide a suitable foundation for managing activities relating to seaweed aquaculture.

Abstracts

Regenerative Ocean Farming in New Zealand

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Seaweed farming has been identified by government and industry as having strong economic prospects for NZ, and as a tool to help combat climate change. To date, there has been limited interest from the established NZ aquaculture industry to use consented water space for farming seaweed due to regulatory hurdles, operational uncertainties and commercial risk. As a result, future sector growth is heavily constrained by the lack of a reliable and scalable supply chain for NZ seaweed. EnviroStrat is piloting New Zealand's first Regenerative Ocean Farm (ROF) model using the native brown seaweed *Ecklonia radiata* kelp as a fundamental crop. The ROF model involves the co-cultivation of compatible zero-input marine species like mussels and seaweed that will create additional revenue streams for the farmers while generating positive environmental outcomes before the crop is harvested. At the heart of the ROF model are profitable independent marine farmers from local communities that build economic and social resilience for coastal communities. The pilot is led by EnviroStrat, in collaboration with the University of Waikato, Premium Seas, AgriSea, University of Auckland, and Māori tribes Ngāi Tai ki Tāmaki and Ngāti Pūkenga. This pilot will establish an end-to-end supply chain, optimising hatchery production and productivity of seaweed farming, and enabling future sector growth. It will consider the influence of different biophysical and environmental factors on growth rates, different growing mediums and farm structures, and impacts of seaweed farming on nutrient uptake, biodiversity, and carbon sequestration.

Abstracts

Selection of local green algae species for growth in Integrated Multi-Trophic Recirculating Aquaculture Systems (IMRAS)

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Application of land-based recirculated aquaculture systems (RAS) is promising for expansion of the aquaculture production in Nordic countries (Dalsgaard et al., 2013). Seaweeds can potentially be used in land-based Integrated Multi-Trophic Recirculating Aquaculture Systems (IMRAS) to capture N and P, while creating a source of revenue through seaweed commercialization (Bruhn et al., 2011). However, vast differences in growth characteristics can be found between different local species/strains (Lawton et al., 2021). In the present study, growth rates and C/N contents were compared from a growth experiment, in a high-nutrient pilot scale setup, including 9 different local green algae species/strains. From the 9 tested species/strains, *Ulva compressa* and *Ulvaria obscura* was selected for further tests of the effect of temperature (10, 16, 22 and 28 °C) on growth, photosynthesis rates, chlorophyll/carotenoid and C/N-contents. The effect of temperature was significantly different for the two species with highest growth rates at 22 °C for *Ulva compressa* (18.9 ± 1.2 % DW day^{-1}) and at 10 °C for *Ulvaria obscura* (16.3 ± 2.6 % DW day^{-1}). After two weeks, the N content was 4.6 ± 0.35 % DW in *Ulva compressa* and 5.1 ± 0.6 % DW in *Ulvaria obscura*. *Ulva compressa* never sporulated during the growth trials, whereas *Ulvaria obscura* did so at 28 °C. The results show that especially the local selected strain of *Ulva compressa* could be suitable for cultivation in a land-based RAS system, having consistently high growth rates and N contents

Abstracts

Bioremediation, growth and yield of *Ulva lacinulata* in IMTA system with Abalone and Sea cucumber

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Abalone aquaculture in South Africa is land-based with much dependence on nutrient-enriched formulated feed. This production process generates large volume of dissolved and particulate waste nutrients capable of creating environmental pressure. In this context, a recommendation to mitigate the potential environmental impacts caused by abalone waste would be using and recycling these waste nutrients considered as pollutants, in an eco-efficient way, with methods such as the IMTA. This system integrates the culturing of organisms with different and complementary ecosystem functions. This study which forms a part of the European Union H2020 Aquavitae project aimed at examining the bioremediation potential and growth of the green seaweed, *Ulva lacinulata* cultured in an IMTA system with abalone and sea cucumber. For such, two systems were set up: (1) *Ulva* cultivated with abalone, (2) *Ulva* cultured with abalone and sea cucumber. Significantly the same growth rates of *Ulva* (20.56 - 20.02 % d^{-1}) were recorded for both production systems (Student's t-test = 2.56, p = 0.06). The daily biomass yield of *Ulva* farmed in abalone effluent was significantly higher than the yield of *Ulva* cultured in abalone-sea cucumber effluent (Student's t-test = 2.97, p = 0.04). The TAN removal efficiency by *Ulva* cultured in abalone effluent (85.6%) was similar to that of *Ulva* (95%) cultured in abalone-sea cucumber (Student's t-test = 1.59, p = 0.19). Likewise, phosphate uptake efficiency (50.01 - 52.78 %) of *Ulva* was similar for the two systems (Mann–Whitney U = 3.00, n1 = n2 =3, p = 0.66). This study shows that *Ulva lacinulata* is very efficient in restoring water quality of abalone effluent and useful in alleviating the environmental impact derived from the high load of nutrients contained in abalone effluents.

Abstracts

Technical feasibility of integrating red macroalgae (*Gracilariopsis tenuifrons*) to a recirculating aquaculture system with clownfish

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We set a total of four systems, each on composed by a black-cylindric fish tank (45 L) in recirculation with a white-rectangular alga tank (20 L), filled with synthetic seawater, for 91 days. Alga tanks were stocked with 38 g of female gametophytes (*Gracilariopsis tenuifrons*) and fish tanks with 80 individuals (*Amphiprion percula*; ~39.0 $mg.ind.^{-1}$). Photosynthetically active radiation was ~100 $\mu mol\ photons.m^{-2}.s^{-1}$ (12h $light.d^{-1}$). Fish were fed twice a day and tanks were siphoned three times a week to remove particulate solids. Partial water change (PWC) was done when tanks showed higher values of measured nutrients. Mean values for salinity, temperature and pH were 35 ± 1, 25.9 ± 0.6 °C, and 8.07 ± 0.23, respectively. Mean value of NH_4-N was 0.01 ± 0.00 $mg.L^{-1}$. NO_2-N showed an increase in the first 40 days, reaching 2.0 ± 1.0 $mg.L^{-1}$, but followed by a fast decrease, reaching a mean of 0.2 ± 0.2 $mg.L^{-1}$ until the end. NO_3-N and PO_4-P accumulated, reaching a mean of 16.6 ± 4.4 $mg.L^{-1}$ and 4.9 ± 1.3 mg.L-1, respectively. *Gp. tenuifrons* showed a constant growth, reaching a mean mass of 131.3 ± 31.3 g (mean growth rate of 1.4 ± 0.8 $\%.d^{-1}$). Fish reached commercial size (498 ± 49 mg) with 97 ± 2% of survival. We did eight PWC per tank, resulting in a production of ~7 fish per kg of commercial salt. Using *Gp. tenuifrons* may be an opportunity to reduce effluent and to increase profitability in marine ornamental fish aquaculture. FAPESP 2019/09269-9.

Microbial dynamics of an integrated aquaculture system using seaweed as shrimp pond effluent biofilter

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Seaweeds are distinguished biofilters which can be successfully grown in Integrated multitrophic aquaculture (IMTA) systems, absorbing nutrient waste, while promoting nature bioremediation. Although the benefits of integrating seaweed to IMTA is indisputable, its role towards its microbial community is still poorly understood. Therefore, a study has been conducted in a tropical prawn farm effluent water treatment system to investigate the microbial dynamics in three sediment pond stages and in a slow sand filter (SSF) located in one of the stages. Amplicon sequencing approach was used to characterize the microbial community associated with the ponds water (n=39), sediment (n=18), SSF (n=20) and seaweed (n=30). Additionally, seaweed composition and abundance were characterised for each stage. The results indicated that SSF promotes microbial biodiversity and evenness increase, while reducing populations of bloom-forming Cyanobacteria. Actinobacteria, Proteobacteria, Cyanobacteria and Flavobacteria were dominant microbial groups in the water, while sediment microbiome was majority composed of Gammaproteobacteria, Cyanobacteria, Deltaproteobacteria and Alphaproteobacteria. Planctomycetia and Verrucromicrobia were amongst the most abundant microbial groups associated with seaweed, encompassing functionally relevant microbes which can play key roles in ammonium oxidation, carbon, phosphorus, and nitrogen fixation. Ecological descriptors highlighted a positive correlation between microbial diversity and seaweed abundance, which negatively corelated with the occurrence of opportunistic pathogen groups and fermentative anaerobic sulphate reducing microbes. This study indicates that integrating seaweeds in IMTA systems potentially contributes towards a heathier and more functionally diverse microbial community.

Abstracts

Stakeholder perceptions on the implementation of Integrated multi-trophic aquaculture (IMTA) in Tasmania: A Q-methodology approach

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Integrated multi-trophic aquaculture (IMTA) refers to the coproduction of species from different trophic levels such as fed fish (e.g., salmon, trout, and shrimp), organic extractive species (e.g., mussels), and inorganic extractive species such as seaweeds. For an IMTA practice to be implemented, social sustainability is something that should be considered, especially when there may be some uncertainty regarding people's willingness to accept such practices. Social sustainability includes but is not limited to the need to understand and address the following: people's wellbeing, maintaining their cultural values, sense of belonging, attachment to place, procedural and distributive social justice, labour rights, community development, community resilience, trust, and social acceptance. When it comes to establishing new aquaculture practices such as IMTA, stakeholders play an important role in defining and informing social sustainability. Recognising the importance of stakeholder input on the implementation of IMTA, this research analysed the perspectives of knowledgeable stakeholders using Tasmania as a case study. Stakeholder perspectives were analysed using a semi-quantitative interview method (Q methodology). The perspectives indicated that participants were in consensus regarding how the scale of an IMTA system can impact social sustainability and the need to consult and educate the public on both the benefits and detriments of IMTA. The Q-study also highlighted some diverging views: i) the need for an appropriate regulatory framework and transparency, ii) the need to keep coastal communities viable, iii) the need for marine spatial planning to engender trust, and iv) the need for increased capacity for IMTA research and development. Individuals of the same stakeholder group did not share similar viewpoints. The diverging views suggest that different management strategies are needed to achieve social sustainability when implementing IMTA.

Abstracts

The growth of the mussel *Perna canaliculus* and the kelp *Ecklonia radiata* in co-culture mesocosm

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Macroalgal detritus has been widely reported as an important source of nutrition in many species of marine bivalves, especially in temperate regions. Consequently, it could be expected that the commercial culture of the mussel *Perna canaliculus* may benefit from co-culturing with the common kelp *Ecklonia radiata* in New Zealand. To test this hypothesis a 3-month mesocosm experiment was conducted with kelp alone, mussels alone, or kelp and mussels together in 70 litre mesocosms. All mesocosms received 2.0-3.0 mgC of phytoplankton daily, just above the minimum carbon requirement for mussel growth and water in the mesocosms were refreshed completely every 2 days. Two batches of kelp collected from the same location were used over the course of the experiment and switched out at day 45. Mussel shell length was taken at day 0, 47, and 90. The increase in shell length from day 0-47 were greater for the tanks with mussels alone versus mussels and kelp, and the reverse was found from days 47-90. There was insufficient data of the kelp growth during the first batch due to a die off to make confirm any differences between treatments. Measurements of the second batch of kelp indicated that there was no difference in the kelp growth for kelp alone or with mussels. The results of the study indicate that the quality of the kelp detritus may influence the amount of kelp detritus ingested by the mussels. There was no evidence that the kelp would benefit from nutrients released by the mussels.

Abstracts

Biomasonry products from macroalgae: **a design driven approach to developing materials for carbon storage.**

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The building industry has a devastating impact on the environment: it's responsible for nearly 50% of the world's total energy consumption, 40% of global carbon emissions, and to date most construction materials continue to be made from non-renewable resources using energy intensive processes. Lowering the embodied carbon of construction materials requires a transition from fossil derived products to bio-based alternatives alongside the design and development of new materials and products that can stay out of circulation and act as carbon sinks. Algae is one of the most effective mechanisms for sequestering carbon from the environment, and in Australia where farming and aquaculture industries have begun cultivating macroalgae for wastewater management, growing algae for the purposes of water remediation is also producing a substantial byproduct– an abundant and renewable carbon fixing biomass.

This paper examines a range of novel and experimental processes involved in the design of 'biobricks' using macroalgae biomass, and the value of interdisciplinary approaches that combines materials science with design research. It will outline how an investigation into aquaculture waste streams led to the development of a new biomasonry material that can support carbon dioxide removal and provide carbon storage solutions within the built environment. Using the biobricks as a case study in developing high value, long lasting products from seaweeds, this paper discusses potential product applications for seaweed-based construction materials, alongside the benefits these can offer to the building industry and to businesses seeking more sustainable building and construction solutions.

Abstracts

Induction of coral larval settlement by coralline red algae: facilitators, inhibitors and possible mechanisms

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Coral reef ecosystems are declining rapidly due to a multitude of natural and anthropogenic pressures. To decelerate this process, rapid action is required to reduce the impacts of climate change, ocean acidification, and local human activities. The implementation of intervention strategies such as the restoration of coral populations is also needed. A key aspect of reef restoration focusses on the production of coral spat in aquaculture settings, and this requires knowledge of the intimate relationship between coral larvae and crustose coralline red algae (CCA), their preferred settlement substrate. In this study we tested larval settlement preferences of 15 coral species for 15 common species of coralline red algae from the Great Barrier Reef to identify important CCA inducers (and inhibitors) of settlement. To understand potential mechanisms driving these interactions we examined the metabolomic profiles, anatomical and morphological characteristics and phylogenetic relationships of the CCA, in relation to the strength of their settlement cues. All CCA induced some level of coral settlement but the family Lithophyllaceae, was overall the best inducer across most coral families. Characteristic metabolomic composition and the lack (or reduced abundance) of trichocytes (surficial translucent hairs) may explain the preference of coral larvae for Lithophyllaceae. Ongoing studies using Lithophyllaceae species will elucidate chemical pathways involved in the interactions between coral larvae and CCA, such information is critical to optimise methods for coral propagation in aquaculture and for the restoration of degraded coral reefs.

Abstracts

Influence of substrate material and surface texture on algal colonisation and coral recruitment success

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To accelerate the recovery of coral reef systems, restoration efforts are being undertaken globally, including the use of sexually propagated corals. One of the main bottlenecks in upscaling the propagation of sexually derived corals is the high mortality of newly settled coral larvae on settlement tiles in marine aquaculture systems due to competitive interactions with macroalgae. While some macroalgal species, particularly crustose coralline algae (CCA), are known to positively influence coral larval settlement success, other macroalgal species have been shown to cause high recruit mortality. However, there is a limited understanding on how different substrate materials and their physical properties can influence the composition of macroalgal communities colonising the substratum and consequently coral recruitment success. Herein, we performed a mesocosm experiment using three substrate material types (i.e., 99.8% partially sintered alumina, concrete, calcium carbonate) with five surface texture classes ranging from 0 to 600 μm and assessed how macroalgal community composition varied across 10 weeks. Following six weeks of tile conditioning, a choice experiment using *Acropora tenuis* coral larvae was conducted to determine coral settlement success. Newly settled larvae were monitored for four weeks to examine their survivorship and interactions with macroalgal taxa. Overall, results from this study provide insights on the synergistic roles of macroalgae, substrate material type, and surface topography on the recruitment success of coral larvae, which contribute to improving the cost-effectiveness and scalability in using sexually propagated corals for restoration projects.

Impact of light on tropical crustose coralline algal communities growing on artificial substrates in aquaculture

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Crustose coralline algae (CCA) are fundamental to the health of tropical marine ecosystems in that they are the mortar binding reef together as well as species-specific mediators of larval settlement and metamorphosis for corals and other invertebrate taxa. It is well established that light is an important driver in marine ecosystem processes, yet little is known about how light quality and intensity impact CCA communities, particularly in aquaculture settings. In this study, we tested the influence of light spectra and irradiance on CCA community structure and composition growing on artificial substrates in culture. Settlement tiles were conditioned with CCA in flow-through tanks at the Australian Institute of Marine Science (Townsville), and then separated into aquaria exposed to three different light spectra (blue dominated, green dominated, and full-spectrum) at four distinct irradiance levels (ranging from 5 to 220 umol). Algae were identified using morpho-anatomy and DNA sequencing. Initial results indicated that light quantity impacted community composition and morphology of CCAs, but spectrum had no considerable influence on species composition. Communities were dominated *by Lithophyllum* sp. followed by *Porolithon* spp. and *Mesophyllum* spp. These results may help inform optimal light conditions for propagating target CCAs for the purpose of settling coral in aquaculture and reseeding coral populations in degraded coral reefs in the Great Barrier Reef.

Abstracts

Competitive interactions in marine environments for space, light, nutrients, and herbivory in seaweeds

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Algae are the staples of most marine environments. Paramount in influencing their distribution are light, space, nutrients, and herbivory. Thus, this work aimed to identify and quantify the current and past literature (1934-2022) on competitive interactions in seaweeds and to address the main questions on the patterns of competition and their consequences for community structure, as well as the comparisons made on the competitive capacity among different macroalgal taxa. To this avail, a quantitative literature search was done based on articles published from 1934 to 2022, using the following combination of Boolean operators and keywords: "Seaweed OR macroalgae OR macroalga, AND ecolog *, AND competiti *". A total of 173 papers were thereafter compiled and selected. Our results contained 124 different genera of seaweeds in works on competition processes. 38% of the compiled taxa belonged to Ochrophyta; 31% Rhodophyta, and 18% Chlorophyta. The best-studied genera were *Dictyota* (6.8%), *Sargassum* (6.8%), *Ulva* (4.9%), *Lobophora* (4.2%), and *Fucus* (3.1%). Space was the most analysed resource (40.9%), seconded by studies related to herbivory (26.1%), and lastly by competition over nutrients (15.1%). The results, while attesting to the overarching complexity of competitive interactions, nevertheless allowed us to summarize the current knowledge regarding the patterns of competitive interactions on seaweeds, thus providing a useful synthesis for new perspectives on marine systems and research.

Macroalgal physiological-ecology across an environmental gradient of submarine groundwater discharge conditions at Waiʻalae, Hawaiʻi

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While polluted submarine groundwater discharge (SGD) has been linked to algal bloom conditions on nearshore reefs, neither macroalgal physiological response to SGD nor benthic community ecology under SGD conditions are well understood. A cryptic yet common feature on basaltic coastlines, SGD delivers tidally-driven semidiurnal pulses of fresh, nutrient rich basal groundwater to Hawaii's nearshore ecosystems. SGD influenced nearshore ecosystems are characterized by daily oscillations in salinity, temperature, and nutrient availability. Natural gradients of SGD influence on nearshore reefs may have provided strong selective pressures on macroalgal species, leading to niche partitioning along this gradient. To examine the influence of SGD on nearshore macroalgal physiology and ecology a multi-factor analysis is employed. Field characterization across a gradient of polluted SGD influence measures physiological responses in photosynthesis and tissue water potential regulation by four macroalgal species to SGD conditions at Waiʻalae Beach. Comparisons are made across two species pairs, closely related invasive *Gracilaria salicornia* and cryptogenic *Hydropuntia perplexa*, and invasive *Acanthophora spicifera* and closely related native *Laurencia dendroidea*. Measurably different physiological strategies are exhibited in these species. Additionally, benthic analyses describe community diversity and structure across the SGD gradient. Benthic analyses reveal the highest macroalgal coverage, low diversity, and invasive species dominance nearest to SGD seeps, while higher diversity, low macroalgal coverage, and more native species occurred at the offshore, non-SGD influenced site. We discuss implications for the role of SGD and algal physiological response to SGD for watershed management and ecosystem restoration.

Abstracts

Seasonal changes in Zonation of macroalgae on a tropical rocky shore

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Rocky shores are highly dynamic and the zonation of species is universal despite the geographic location. Pollution and unregulated fishing in many developing nations threaten this sensitive ecosystem altering the species composition. Macroalgae cover of Ahangama Kanda rocky shore in Southern coast of Sri Lanka was analyzed during two monsoon seasons in 2022 (northeast/ southwest). Approximately 30-40 photo-quadrates (50 x 50 cm) were used for the analysis of species composition in five zones depending on tidal movement (near shore/intermediate/ sheltered middle zone /sheltered reef edge/ wave breaking zone). Images were analyzed using CPCe software (4.1) and differences between zones were analyzed using ANOSIM in PRIMER V6 software. Sixteen and fifteen species of macroalgae were recorded for the Ahangama Kanda reef in the southwest and northeast monsoon, respectively. ANOSIM results revealed significant differences between species composition of zones (R=0.743, p=0.1%). The Nearshore zone was dominated by crustose coralline algae and the abundance doubled during the southwest monsoon (51.26 ± 4.5%). The intermediate zone was dominated by turf algae (39.38 ± 3.16 %) and *Halimeda* sp. (40.16 ± 3.82 %) during the northeast monsoon and southwest monsoon respectively. Wave breaking zone was dominated by *Carpopeltis* sp. whilst the sheltered middle zone was dominated by *Sargassum* sp. during both seasons. Nearshore zone and wave breaking zone were significantly different (R= 0.937, p=0.1%) and the difference was attributed to *Carpopeltis* sp. (27.74%) and turf algae (20.70%). The dominance of different species in each zone indicated clear zonation and long-term monitoring is essential to conserve this habitat.

Abstracts

Gametes of the green seaweed *Ulva mutabilis* (Chlorophyta) under cupric stress

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Unfortunately, pollution caused by mine drainage is more common than we think. Untreated copper wastes flowing directly into a bay resulted in massive mortality of fish and molluscs (Castilla and Nealler 1978). However, *Ulva compressa* was unmistakably a visible aquatic organism inhabiting the discharge site, suggesting tolerance to high copper concentrations (Vermeer and Castilla 1991). To date, this discovery has prompted copper studies in *Ulva compressa* (Moenne et al. 2020).

Chemical signals are important interaction mediators between organisms that significantly impact ecosystems. Ecologists and analytical chemists work closely to identify the specific molecules that regulate ecological interactions, and metabolomics techniques have allowed for significant progress in this area. Despite numerous studies on *Ulva* and its tolerance to copper, no consideration has been given to potential interactions with its associated bacteria as producers of metallophores (i.e., organic ligands) that could act as a copper buffer, becoming a sequester mechanism.

Thus, using *Ulva mutabilis* as a model organism, an untargeted metabolomics approach including endo-metabolite extraction was applied to study *Ulva*'s gametes under cupric stress EDTA was used in artificial culture medium to complex copper mimicking the function of Cu-complexing dissolved organic matter. Gametes released into a harmful (i.e. high copper concentration) environment were collected after 24 hours of incubation during their settlement. Metabolite profiling revealed a significant difference between high and low EDTA concentrations at equal total Cu concentrations, supporting our hypothesis that organic matter contributes to copper stress management in the chemosphere of *Ulva*.

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Abstracts

Primary production *in situ* measurements on the subarctic kelp *Saccharina latissimi*

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Kelp communities are major primary producers in subpolar and temperate areas, producing up to 39 Tg C year^{-1} in coastal zones. Kelp beds are not fully considered as blue carbon contributors in spite of their carbon storage capacity: indeed, local sequestration remains limited and most of the organic carbon is exported from the community. Certain limitations also prevent to correctly estimate their blue carbon potential: lack of measurements of organic carbon stocks, sub-optimal evaluation of carbon fluxes and uncertainties about the transport and sequestration of kelp-derived material. For instance, thorough measurements of primary productivity in subarctic kelp beds are scarce and almost never measured *in situ*. To fill in some gaps, we measured *in situ* primary productivity on individual kelps (*Saccharina latissima*) with incubation chambers during natural light and dark conditions, using oxygen flux measurements. As the seasonality is an important component of the sub-arctic systems, primary production was assessed from June to September (spring, summer, autumn). In June 2022, oxygen net production by individual kelp varied from 7.94 to 100.63 µmol O_2 g^{-1} DW h^{-1}. These rates exceed slightly the ones from *in situ* incubations of the kelp *Laminaria hyperborea* in Brittany where the maximum net primary production reached 72.13 µmol O_2 g^{-1} DW h^{-1}. From these oxygen fluxes, carbon fluxes will be calculated using the photosynthetic quotient extrapolated at the population scale to estimate the carbon storage capacity of kelp beds in the St. Lawrence Estuary.

Abstracts

Local adaptation across multiple life stages and populations: implications for the giant kelp *Macrocystis pyrifera* resilience to ongoing climate change

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The ability of seaweeds to adapt and/or acclimate to climate change can differ between different populations, depending on their local environmental history and phenotypic plasticity. Globally, many seaweed populations have been negatively affected by multiple anthropogenic factors such as ocean warming (OW). However, local drivers such as nitrogen (N) might modulate their physiological responses to OW. In this study, we compare the physiological responses and early development of *Macrocystis pyrifera* to different regimes of temperature (stable–fluctuating) from populations naturally exposed to fluctuating conditions of CO_2, pH, temperature, and N. Fertile sporophylls of *M. pyrifera* were collected from populations with high (Las Docas and Punta Lavapiés) and less exposure to upwelling events (El Tabo and Punta de Parra). Temperature, pH and nutrient concentrations were constantly monitored in each locality. At the laboratory, *M. pyrifera* early stages (meiospore, gametes, and juvenile sporophytes) were exposed for three months to four temperature treatments: 16°C stable, 16°C fluctuating, 19°C stable and 19°C fluctuating, simulating the average temperatures during the spring-summer months and OW scenarios. As a result, we observed great variability in the developmental (germination success, gametophytes growth, reproduction success) and physiological responses (growth and photosynthesis) among populations and temperature treatments, regardless of the upwelling effect. These differences might be given by the great variability registered in temperature and pH in each locality. However, the greatest differences among populations were found between gametophytes and juvenile sporophytes, suggesting different adaption capacities among multiple life stages of *M. pyrifera*.

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Abstracts

Effects of marine heatwaves on the kelp *Pterygophora californica* from different depths in Baja California (Mexico).

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Marine heatwaves (MHWs) associated with climate change threaten the productivity and distribution of kelps worldwide. In the Northeast Pacific, kelps find their southernmost distribution boundary in the Baja California peninsula. Here, MHWs have been associated to severe alteration of kelps populations, although specific temperature-kelp´s physiology interactions remain poor understood. Adaptation to different local thermal regimes is among the primary factors that can determine kelps' physiological tolerance and resilience capacities under thermal stress. In this study, we assessed for the first time the physiological plasticity, stress responses, and recovery capacities of *Pterygophora californica* exposed to a simulated MHW and recovery conditions. Controlled experiments were conducted in outdoor mesocosm systems using adult sporophytes collected from shallow (10 m) and deep (25 m) populations, presumably adapted to different temperature regimes. Variables measured included photobiology, oxidative stress, nutrient content (nitrogen, carbohydrates), nitrogen uptake kinetics and growth. Results showed different response patterns between the shallow and deep populations at the exposure and recovery phases. Photosynthesis and nitrate uptake rates were positively affected by temperature in both populations, while only shallow water sporophytes showed oxidative damage and diminished vegetative growth with increased temperature. Elevated thermal tolerance exhibited by deep sporophytes could be related to deep population refugia; this opens the window to potential uses in restoration efforts for this species.

Abstracts

Changes in *Macrocystis pyrifera* distribution in southern New Zealand correlated with elevated sea surface temperature

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The giant kelp *Macrocystis pyrifera*, is an ecosystem engineer, forming kelp forests that provide valuable ecosystem services. Since the 1940's when records began, *M. pyrifera* kelp forests have been declining in some regions of southern New Zealand. Changes in average sea surface temperature alongside more frequent and severe marine heatwaves are breaching the thermal limitations of local *M. pyrifera*. This research determined the current distribution of *M. pyrifera* in the Marlborough Sounds (41°S), near the northern limit of *M. pyrifera* in New Zealand, and a more southerly population in Stewart Island (47°S). Video transects were utilised to rapidly survey the two regions and 49 sites from the Marlborough Sounds and 28 from Stewart Island were compared with previous records of distribution in these regions from 1942 and 1988. Satellite data of sea surface temperatures indicate the warmest water originates in the north-west of both regions, also breaching the thermal thresholds of *M. pyrifera* in these areas. *M. pyrifera* was found to be receding from the north-west of both regions. Therefore, warming sea surface temperature appears to be a primary driver of this decline. The implications of these losses will likely have flow on effects for local fisheries and impact the ecosystem services which kelp forests provide to an extent which is not yet fully understood.

Abstracts

Genetic structure of remnant giant kelp populations on the Tasmanian coast

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Macrocystis pyrifera forms dense kelp forests creating complex habitats that support coastal productivity and other essential ecosystem services. Tasmanian coasts have lost ~95% of their giant kelp forests in the last decades due to changes in climate and other environmental conditions, such as ocean warming. Recent restoration efforts demonstrated that some lineages of Tasmanian giant kelp possess increased tolerance to warmer waters. Little is known about the genetic structure of these giant kelp populations, particularly warm-tolerant individuals; this knowledge is crucial for building a management plan for kelp forest conservation and restoration. Here, we assess the genetic structure of Tasmanian giant kelp with genotyping-by-sequencing (GBS) and explore whether some genotypes correlate with warmth tolerance. Forty-five gametophyte cultures—originating from parental sporophytes collected at three northern and three southern populations of Tasmania—were used to perform GBS with ddRAD-based library preparation. The individuals from the north and the south are two genetically distinct populations, with genetic divergence also evident between sites within each region, particularly the southeast region. This result contradicts prior genetic analysis (using organellar markers or nuclear ITS), which suggested low genetic diversity among populations in Tasmania. Our results show that ten markers are potentially associated with warm tolerance. However, more genotyping markers were correlated to the absence of tolerance. Our findings reveal a higher genetic diversity of *M. pyrifera* than previously thought and provide an introductory foray to the challenges of using conservation genomics for endangered kelp forests to benefit their restoration and natural resource management.

Abstracts

Assessing the role of natural kelp forests in modifying seawater chemistry.

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Kelp forests are some of the most productive, diverse, and high-valued ecosystems on Earth which are threatened by future climate change stressors. In some locations, kelps can play an important role in ameliorating the local effects of ocean acidification through the uptake of CO_2 during photosynthesis. The effects of kelps on local seawater chemistry (pH and O_2) in different environmental conditions remains unknown. Here we conducted a literature search and field measurements to quantify the responses and effects of kelps on seawater chemistry in different hydrodynamic conditions. Our results showed that the proportion of studies which tested the effects of kelps on seawater pH and O_2 was significantly lower than those which assessed the impacts of future changes in seawater chemistry or hydrodynamics on kelps. Field measurements demonstrated that natural kelp (*Ecklonia radiata*) forests had higher values of pH (~0.1 units) and O_2 (2.21 mg/L) during the day than bare rock barren habitat, but the differences were only significant when conditions were calmer. Our results suggest that the benefits of kelp forests in providing local climate refuges to calcified species from ocean acidification are variable through time and could be dampened by the increased wave exposure and storminess associated with climate change

Abstracts

Stipe of the kelp *Eisenia bicyclis* as a potential for long-lasting carbon sink

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Eisenia bicyclis is a dominant stipitate understory canopy-forming kelp on the Pacific coast of Japan. The kelp is perennial with 8 years of longevity. While the blades of *E. bicyclis* are gradually renewed, the stipes are constantly present for supporting blades and have been observed to persist for some time after the loss of blades or the detachment of holdfast. Therefore, the stipes may function as a long-lasting carbon sink, but their contribution to coastal environment have been rarely quantified. In this study, field experiments were conducted to investigate their contribution to carbon storage. Cut pieces of *E. bicyclis* stipe (N = 6), ca 8 cm long were suspended at the depth of 3 m at subtidal rocky shore of Kitsunezaki, Oshika Peninsula, Japan. Changes in their morphology, wet weight and C/N ratio were recorded for two months with ca two-week intervals. The experiment was conducted in different seasons: summer (Jun-Aug, 2021; 24-27°C), autumn (Sep-Dec, 2021; 16-23°C) and spring (Feb-Apr, 2022; 14-22°C) and the results were compared between seasons and analyzed. Stipe thinning was started from the core region with decreasing stipe weight at a rate of 49% (summer), 26% (autumn) and 6% (spring). C/N ratios over seasons were almost constant, but nitrogen contents were 50% lower in blades than in stipes. In conclusion, it is suggested that *E. bicyclis* stipes contribute to coastal ecosystem as a long-lasting carbon sink. Accelerated decomposition of kelp stipes with increasing temperature by global warming can reduce their value as dominant coastal carbon sink.

Abstracts

The Japanese perspective and action regarding seaweed bed restoration

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The coastal fisheries industry in Japan is relies heavily on a stable and healthy coastal ecosystems. However, through the combined and often synergistic effects of industrial pollution, land reclamation, coastal armoring, and over-fishing, kelp, sargassum, and seagrass ecosystems in Japan have quickly declined. The permanent loss of submerged aquatic vegetation is known as iso-yake in the country. Historical instances of kelp restoration date back to the 1700s. But contemporary efforts have been in response to the noted seaweed declines of 20th century. While there has been a significant investment into kelp restoration in the country, including hundreds of attempts at restoration, large scale recovery is still rare. The major instrument for Japanese kelp restoration is the Fisheries Multiple-function Demonstration Project which combines federal, prefectorial, and local funding to launch projects. This talk outlines the current status on seaweed bed restoration in Japan while also highlighting key issues to address for the future.

Abstracts

Cascais Sea Strategy – Kelp Forests as a city's strategic objective in Sustainable Development

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The Kelp Forest restauration project is inserted in Cascais Sea Municipal Strategy. This local strategy seeks the sustainable development of the sea's economic activities, promoting equality marine biodiversity and conservation of its historic patrimony. These objectives are supported by a vast scientific knowledge. The strategic decisions and consequent project development are dependent on this knowledge raised by the Municipality with its academic partners. Along with its technical-scientific dimension the Seas Municipal Strategy is based on a good governance structure by its Sea Municipal Council, composed with more than 40 entities represented by central government, local stakeholders, Academia and NGOs.

Kelp forests have always been a part of Cascais Sea landscape, being very common in some beaches and dearly remembered by the ancient fisherman or sailors. The Seaweed populations started to decrease in the 80's due to unknown causes. To restore the old Kelp Forests in Cascais Sea, the Municipality started to test the "green gravel" methodology in different deployment sites with the SeaForest Association and in 2022 started to test transplants from adult individuals, these projects had funding from the EEA Grants Mechanism. It is expected by the end of 2022 to have a demonstrator artificial reef unit near the transplant sites, where new kelp restauration methodologies will be tested. In a few years the Municipality expects a larger abundance in fish, with greater income for the local fisherman, a return of seaweeds to the beaches and an increase of nautical tourism (namely divers to visit the underwater forests).

Abstracts

Chilean kelps restoration, a review of past, progress, and opportunities by using chimeric kelps (R+D)

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While there is an extensive history of using kelp forests and ecosystems in Chile, there is currently little history of kelp restoration. Most efforts have been motivated to support the harvest of *Macrocystis* and *Lessonia*, which can reach 400,000 dry/tons and 10% of the world's harvest. Harvest decreases wild populations and their associated ecosystem services valued at USD 54 million/hectare. Restocking efforts occur within the context of fisheries management (Law N°20.925). *Macrocystis* actions have been involved in long-line cultivation to obtain commercial biomass. These projects released hatchery-reared plants into the sea, and their costs/benefits analysis were led by collaborations between academics and kelp companies. *Lessonia* species occur on the rocky exposed intertidal, and thus restoration works with outplants on artificial substrates secured onto the benthos. These are typically partnerships between academics and fishery cooperatives and again are viewed as restocking management, maintained over short time scales and small extents. The success varied depending on methodology and season, but a major gap in Chile and indeed globally is the consideration of genetic composition. Recently, researchers have sought to increase stocking and restoration success by using chimeras of *L. spicata* and *L. berteroana* (PatentCL201701827). In the lab chimeras have improved temperature tolerance. In the field, chimeras increased survival, growth rate, and genetic diversity at pilot scales compared to homogenous plants, improving the success rate of restoration projections. This work highlights the need to synergistically consider genetic diversity, resilience, and climate change mitigation factors to ensure sustainable management and development.

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Abstracts

Seaweed restoration in Australasia

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Although kelp restoration has a relatively short history in Australasia, there has been a surge of interest and investment in the last decade. This talk aims to summarise current projects underway across Australia and New Zealand, focusing on highly innovative approaches to restore multiple Fucales and Laminariales species. Large-scale *Ecklonia radiata* restoration efforts along the east coast of Australia have mostly focused on the removal of sea urchins, via a combination of extensive targeted removals, culling, fisheries harvesting, and urchin roe conditioning. In Western Australia, a new restoration method – Green Gravel – is being developed to seed lab-cultured E. radiata over large areas affected by a major heatwave in 2011 without expensive scuba diving operations. In southern Australia, pioneering multi-habitat restoration efforts have identified important ecological synergies, whereby transplanted *E. radiata* forests increase oyster recruitment and facilitate seagrass recruitment. In Sydney, innovative art-meets-science approaches combine the restoration of the fucoid *Phyllospora comosa* with high profile community engagement activities, thereby raising awareness about kelp forests more broadly. In New Zealand, restoration with multiple species focuses on responses to future stressors and developing selective breeding strategies. This includes extensive work with giant kelp *Macrocystis pyrifera*, which is also a major restoration target in Tasmania. Multiple groups throughout Australasia are combining genomic tools and experiments to map genetic differentiation within species, to identify genotypes that may be included in restoration efforts to enhance resilience to future conditions.

Abstracts

Piloting bull kelp (*Nereocystis luetkeana*) cultivation strategies to support kelp restoration and recovery in California

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In many regions around the world, kelp forests are facing unprecedented declines. 96% of bull kelp (*Nereocystis luetkeana*) forests in northern California, USA, have disappeared in less than a decade––devastating both ecosystems and livelihoods. Restoration of depleted kelp forests may require multiple interventions, and resource managers need more tools in the restoration toolbox. Urchin removal, artificial reefs, and transplantation of wild kelp from healthy beds to restoration areas have been deployed in California with varying degrees of success. Kelp farming is another strategy that offers the potential to support statewide kelp restoration efforts, but cultivation practices for bull kelp are underdeveloped. GreenWave, together with The Nature Conservancy and Hog Island Oyster Company, tested bull kelp cultivation strategies in Humboldt Bay, California, to optimize farm designs and evaluate the potential of cultivation to support restoration of depleted bull kelp beds along California's North Coast. GreenWave's farm site is the first in the state of California to be commercially licensed to cultivate bull kelp. Approximately 480 meters of seedstring, produced using traditional meiospore methods, was outplanted onto a combination of 5-line and single-line arrays at the pilot site in October 2021 and March 2022. Yields during the first harvest ranged from 17 to 35 kg per meter on the 5-line and single-line arrays, respectively, with abundant sorus production. Preliminary results indicate that the array designs and site characteristics in Humboldt Bay are conducive to bull kelp cultivation, with an opportunity for multiple outplantings and harvests per year that will support restoration efforts.

Abstracts

The value of the world's kelp forests

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Kelp forests cover over a quarter of the world's coastlines and provide extensive benefits to people. Yet, even though interest in kelp forests has increased in the past decade, our understanding of the prevalence and value of these contributions – or ecosystem services – lags decades behind other ecosystems. We lack a spatiotemporal understanding of the ecosystem services provided by kelp forests across their global range, and current economic valuations are sparse and regional, and heavily dominated by direct-use services such as fisheries and kelp harvest. This underestimates the value (*sensu lato*) of kelp forests considerably because they do not consider cultural values or many other ecosystem services such as carbon storage, nutrient filtration and biodiversity provision. Importantly, kelp forests continue to decline globally and efforts to restore and protect these habitats have substantially lagged behind other coastal ecosystems. This talk will present the findings of the Global Ecosystem services Assessment from Kelp forests (GEAK) network – a network that includes 32 kelp and seaweed experts and environmental economists. Over the past 2 years, the network has compiled biophysical and valuation data from 65 ecoregions. Using a common data collection protocol based on the IPBES framework, the network has quantified the prevalence of ecosystem services from kelp forests in 65 ecoregions globally and developed a total economic valuation of these services. We also quantified the trend in these services over the last two decades and identified key knowledge gaps across these ecoregions. Recognition of the value of the services provided by kelp forests will provide an impetus to restore and protect these ecosystems and help meet international targets concerning ocean accounting and ecosystem assessments.

Abstracts

Applications of seaweed extracts in Australian agriculture

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The world population is growing rapidly and relies on agriculture to produce food in productive, safe and sustainable ways. Agriculture needs innovations to improve the way resources like water, nutrients and fertile soils are used. Food production needs to be resilient to increasing climate volatility and extremes. Seaweed extracts are a key part of productive, sustainable and regenerative agriculture. Seaweed extracts have proven properties that reduce yield losses caused by abiotic and biotic stress events and improve nutrient utilisation. An understanding of the mechanisms that contribute to the beneficial effects and effectiveness of seaweed extracts in the field is a priority. This is particularly relevant for Australian agriculture where the impact of climate volatility is significant. The benefits of seaweed extracts to crops have previously been reviewed in the context of the northern hemisphere, but not recently in the context of Australia, its crops and unique stressors. In Australia, seaweed extracts have been studied in the field across different crops and farming systems. In the laboratory, the effects of seaweed extracts on model and crop plants have been studied to discover the plant molecular, cellular and physiological responses they cause. Their molecular mechanisms of action have been studied to characterise the processes that seaweed extracts use to condition plants. Therefore, we review the research on seaweed extracts to provide insights for the applications of seaweed extracts in Australian agriculture.

Abstracts

Effect of seaweed biostimulants on reactive oxygen species, disease suppression and higher yields in strawberry

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We evaluated the effectiveness of a commercial seaweed extract from *Durvillaea potatorum* and *Ascophyllum nodosum* (Seasol®) on the yield, revenue and post-harvest rot of strawberry fruit in a series of field experiments. In the experiments, we treated strawberry plants (cv. Albion) monthly with a combined drench (10 L ha^{-1}) and foliar spray (1:400) of the extract, compared with equivalent volumes of water as a control. In the strawberry nursery sector, use of the extract significantly increased the density of secondary roots (feeder roots) on harvested transplants by up to 22% and yields of marketable transplants by 8–19%. In the fruit sector, use of the extract significantly increased the root length density (root length per volume of soil) of strawberry plants by 38%, marketable fruit yields by 8-10%, and revenue from fruit by A$0.37-0.59 $plant^{-1}$. Root length density at final harvest and marketable fruit yield of strawberry were highly correlated ($r = 0.94$), indicating a role of the extract in increasing the functionality of the root system. This was associated with a 9% increase in nitrogen-use efficiency by the crop. The extract significantly reduced the incidence and severity of post-harvest rots in strawberry fruit by 52% and 87%, respectively. The extract did not affect the firmness, soluble solids concentration (SSC), titratable acidity, or SSC:acid of strawberry fruit. In laboratory experiments, treatment with the extract increased the concentration of reactive oxygen species in strawberry roots. This provides evidence that the extract primes strawberry for tolerance against biotic and abiotic stress factors that affect disease, yield and quality.

AGFORT, a red seaweed-based product and its implications in crop protection

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Seaweeds are known to host a diverse set of bioactive compounds. These compounds have been mostly exploited in agriculture either as fertilizers or as bio-stimulants for various abiotic stress management. In fact, numerous bio-stimulant products are commercially available. However, the roles of seaweed bio actives in crop protection segment remains less exploited commercially. Most findings of seaweed bio actives in biotic stress management are limited to academic research. Herein, we describe the plant immune boosting activity of a *Kappaphycus* derived formulation AGFORT and its role in crop protection. AGFORT contains unique, proprietary sulfated sugars that can trigger plant immune system. Prophylactic, foliar application of AGFORT, enhances the levels of defense related phytohormones, salicylic acid and jasmonic acid. The relative expression levels of various defense genes are enhanced within 24 hours of AGFORT application. Further our biochemical studies suggest AGFORT has no direct action on plant pathogens. Based on these insights a model is hypothesized to describe the potential mechanism of action of AGFORT. Further, field trial studies conducted in disease prone hotspot regions indicate lower virus disease incidence and reduced disease severity when primed with AGFORT product. An average of up to 60% disease reduction was observed from various trials. Overall, our studies suggest AGFORT product possess broad-spectrum immune boosting activity in plants and thus could serves as a natural, eco-friendly option in sustainable agriculture.

Effect of a fortified Seaweed Extract on tomato physiology, productivity, fruit quality and soil properties

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Productive soils rely on soil ecosystem processes and the nitrogen and carbon cycles being synchronized. However, in depleted soils that are farmed intensely with limited crop diversity, the natural ecosystem processes become disconnected. Similarly, a dependency upon inorganic fertilizer eventually results in fragmented biological, plant, soil and microbe ecosystems.
New innovations are needed to boost, connect and regenerate the soil processes for better agricultural productivity and longer-term soil fertility. Our hypothesis is that the combination of seaweed extract, amino acids and complex carbon-rich humate fractions are key ingredients for simultaneously boosting soil biology and increasing crop productivity. A product was made from these ingredients called Seasol Trilogy 631. The product was applied to tomato plants potted in fertilized soil, grown in a greenhouse and arranged in a replicated trial design. The crop was tested for (i) plant physiology (such as root biomass, flower timing, flower number, fruit set and fruit number, and leaf SPAD) (ii) crop productivity (harvest yield, fruit weight and number per plant), (iii) fruit quality (size, count, brix) and (iv) soil properties (total bacteria and fungi counts). We present results that the product was successful in simultaneously enhancing tomato plant physiology and productivity while improving soil biology.

Abstracts

AgroGain®, prepared from *Kappaphycus* improves growth of *Cucumis Sativa* by modulating developmental and physiological processes

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To feed the growing population, the agricultural productivity must be doubled by 2050. In current scenario, the agricultural domain is basically relying on extensive use of chemical fertilisers to increase growth and productivity of plants. Biostimulants are the new class of sustainable agriculture inputs that are known to have beneficial effect on plant growth and productivity. In this study we have demonstrated that *Kappaphycus alvarezii* derived biostimulant, AgroGain®, rich in sulphated galacto-oligosaccharides, induces the expansion of the cucumber cotyledon. After 7 days of treatment, AgroGain® supplemented cotyledons show 29.2% increase in area of expanded cotyledon as compared to control. The gene expression analysis carried out on cucumber cotyledon revealed that AgroGain® treated cotyledon differentially modulated the expression of genes involved in cell division, cell number, cell expansion, cell size, and phytohormone biosynthesis. Further, foliar spray of the AgroGain® on the cucumber plants grown under hydroponics conditions shows improved plant growth as compared to control. Total leaf area of AgroGain® sprayed plants was increased by 19.1% than the control. Photosynthetic efficiency of AgroGain® sprayed cucumber plants was found to be higher via increased photochemical quenching and reduced non-photochemical and non-regulatory quenching. AgroGain® application also modulated change in the steady state photosynthetic parameters in cucumber leaves. The rate of linear electron flux (LEF), proton conductivity (g_{H}^{+}) and steady-state proton flux (v_{H}^{+}) across the thylakoid membrane was found higher in AgroGain® sprayed plants, suggesting that bioactive compounds present in AgroGain® improves the growth of cucumber plants by regulating the physiological and developmental pathways.

Abstracts

Study of holopelagic *Sargassum* in carribean coasts: development of extracts for agriculture application

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The SAVE-C project is dealing with the knowledge gaps about the ecology of the *Sargassum* raft on the coast and their threats in the Caribbean, but also suggest solutions to transform the abundant biomasses of macroalgae stranded on the beaches into socio-economic opportunities. Using a multidisciplinary approach of field studies, ecological and physiological experiments, and biotechnological processes, the project SAVE-C will: (1) develop knowledge on *Sargassum* species responsible for the seaweed-rafts and their beaching's, (2) collect and develop storage solutions for huge biomasses of *Sargassum* before its industrial application in both agriculture and biomaterials.

The present work is dedicated to analysis and biomasses valorisation (WP5, Algaia-Coleader). First results lead to a well of knowledge on chemical composition of the 3 morphotypes (*Sargassum Natans* III, *Sargassum Natans* VIII and *Sargassum fluitans*) in comparison to *Sargassum muticum* harvesting in France (Normandie). A part will be dedicated to the seasonality study and comparison in terms of fucoidans, laminarans, alginates, mannitol and phenolic compounds, and another one on liquid extracts produced. Those metabolites are targeted for the development of seaweed biostimulant production. First results on agronomical tests will be also revealed. A biorefinery concept at large scale will be drafted to provide recommendations regarding valorization of this huge quantity of *Sargassum* matter.

Abstracts

Review of an ecosystem approach to the *Ascophyllum nodosum* harvest in Canada, 27 years later

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Until 1995, the harvest of *Ascophyllum nodosum* in Canada only took place within the province of Nova Scotia and under a "laissez faire" management. However, due to an increased demand for products derived from this seaweed, and an increased competition for this resource, the industry showed an interest to harvest, for the first time, the abundant and pristine resource found in the neighboring province of New Brunswick (NB). This interest coincided with the recent collapse of the ground fishery in Atlantic Canada in the early 90's. This led the country to change its fisheries management from a single-species sustainability to an ecosystem approach. *A. nodosum* had long been recognized as both a resource and a habitat, consequently, the expansion of the harvest to NB created concern among local stakeholders, government, and scientists. Thus, before the harvest could expand to NB, a new ecosystem-based management strategy that integrated its role as a habitat had to be developed while considering stakeholders and socio-economic issues. Provisions to protect the surrounding habitat and to minimize the ecological impacts of the harvest were developed by applying area-based management at a high spatial resolution. These provisions included regulating harvesting gear, establishing a conservative exploitation rate, and creating special management areas to protect waterfowl and closed areas as long-term reference areas. This program represents a rare case in marine fisheries where all the regulations were in place before the harvest started. The success and challenges of this management program 27 years after its initiation is presented here.

Abstracts

Ascophyllum nodosum Le Jolis Harvesting Impacts and Management Options Using GPS Tracking of Mechanical Harvesters in Nova Scotia, Canada

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Area based management of *Ascophyllum nodosum* Le Joli in the Canadian Maritimes has advanced over the past 60 years from open buying stations in Bays to quota based area management under coastal leases. In 1989 the resource was divided into geographical sectors containing .9 to 17.6 ha containing 92 t to 2105 t of biomass. Sectors are the units of management plans under guidelines of the provincial government. GPS tracking mechanical harvesting to Nova Scotia began in 2017 in a pilot harvest. The yield was corelated with the time, distance, and cutting swath. Harvests were conducted within target bed polygons of 200 m^{-2} to 1280 m^{-2}. Production per hour averaged 1120.7 + 164 kg h^{-1} yielding 4.9 + 2.1 kg m^{-2} of swept track. The exploitation rate was calculated for 12 polygons based on the preharvest harvestable biomass of 10 kg m^{-2}. The average exploitation rate at this scale was 11.12 + 3.23 %. This level of geographic resolution of the harvest permits significant improvements in management practices, control of management plans, pre and post assessments of the resource. It is a tool to address landscape scale questions related to ecologically sustainable harvesting.

Abstracts

Optimising kelp cultivation on the West coast of Scotland.

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Interest and demand in cultivating seaweeds has been growing rapidly in Western Europe, driven by the continuously developing expertise and markets for a variety of food and non-food applications. The Scottish Association for Marine Science (SAMS) has been operating an experimental seaweed farm for almost ten years, conducting industry-driven research to improve seaweed cultivation methods for optimal biomass yields and quality.

To identify the optimum time for harvest we followed biomass yield, morphology, composition, and trace elements in two cultivated kelp species (*Saccharina latissima* and *Alaria esculenta*) at nine consecutive harvest times between March and July 2020. Yields and biochemical composition differed across species and harvest times, affected by prevailing environmental conditions (temperature, light, and nutrient levels) that vary throughout but also across cultivation cycles. In addition, specific growth rates of *A. esculenta* peaked earlier in the season than *S. latissima*. This was also reflected in the temporal difference for maximum yields (early-June for *A. esculenta* and early July for *S. latissima*) whilst progressing biofouling pressure increasingly affected yield and quality estimates.

Our results highlight the dramatic variability in kelp performance throughout the harvest season as well as the complex relationships with environmental cultivation conditions. The optimal harvest time will vary depending on the intended application, with an early harvest recommended for food applications (low fouling pressure, heavy metal and iodine accumulation) and a later harvest for maximised yields and carbohydrate contents.

Strain selection for aquaculture of *Saccharina latissima* in a freshwater-influenced fjord system in North Norway

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Aquaculture of marine macroalgae is an important part of the world's food production. In Norway, the fast-growing kelp *Saccharina latissima* has the highest potential for industrial biomass production. Aquaculture in the country's fjords is economically more viable for SMEs, supports the development of IMTA and could allow the industry to approach the projected 20 million tons by 2050. However, *S. latissima* is exposed to a considerable decline in seawater salinity during the growth season, which affects the biomass production. This presentation shows results of industrial R&D projects in which the presence of "low-salinity tolerant" strains of *S. latissima* in a North Norwegian fjord and their responses to the seasonal salinity decline was studied. In a laboratory-based common garden experiment, sporophytes of *S. latissima* from different locations in Skjerstadfjorden were cultivated under different salinities for six weeks. Growth and photosynthetic parameters were measured to understand their physiological responses to salinity stress. Then their F1 generation were seeded on ropes and deployed at a commercial aquaculture site in Skjerstadfjorden to study strain-specific differences in biomass production and yield, optimal growth depths and biochemical composition of *S. latissima*. In addition, the aquaculture site was characterised by measurements of physical and chemical parameters. The projects' results will help North Norwegian macroalgae producers to improve the biomass production and biochemical composition of *S. latissima*. These findings could lay the foundation for the development of breeding programmes in Norway and could demonstrate the macroalgae producers in Norway the possibility of establishing aquaculture in fjords.

Abstracts

SeaMark: Seaweed Based Market Applications

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SeaMark is a four-year project that has been awarded a prestigious €9 million Horizon Europe grant to upscale seaweed production and market applications across Europe. The consortium is led by Ocean Rainforest comprising 25 international, cross-disciplinary partners. SeaMark will utilise recent ground-breaking selective breeding technologies within EU seaweed crop genetics to increase biomass yield. SeaMark aims to upscale circular ocean seaweed cultivation and land-based integrated multitrophic aquaculture (IMTA) systems and develops novel processing methods involving fermentation and biotransformation into twelve innovative seaweed-based products. The entire value chain will be analysed for techno-economic feasibility and socio-economic impact. SeaMark will also identify and quantify ecosystem services provided by seaweed cultivation. This will feed into a strategic development plan for upscaling seaweed production and addressing the carrying capacity of seaweed cultivation in Europe. Due to the need to build more resilient food systems and decrease reliance on fossil-based products, it is necessary to grow the blue bioeconomy through seaweed cultivation and product innovation. SeaMark will help fulfil the United Nations Sustainable Development Goals by developing this industry and, simultaneously, providing a positive impact on people and the planet. The project commenced on July 1, 2022, and the presentation will focus on the preliminary results and the project goals.

The reproductive phenology of *Asparagopsis armata* in New Zealand – 35 years later

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The reproductive cycles of seaweed are typically controlled by both endogenous and environmental factors related to seasonal change, such as temperature, light intensity, and photoperiod. In particular, gametogenesis and sporogenesis are mediated by temperature for approximately 70% of temperate seaweed species where this has been quantified. Therefore, it can be expected that increases in water temperature due to climate change causes shifts in the reproductive phenology (the timing of key events in the reproductive cycle) of seaweeds. This has become an increasingly common phenomenon for a range of organisms from different terrestrial and aquatic taxonomic kingdoms, however, to date, research on the effects of climate change on the reproductive phenology of seaweeds is lacking. Instead, the majority of related research focus on geographical shifts in the distribution and abundance of seaweed populations. We therefore conducted monthly field sampling of the red seaweed *Asparagopsis armata* over 18 months at Matheson's Bay, North Island, New Zealand, and quantified presence/absence of reproductive structures, and reproductive maturity and viability of naturally released carpospores and tetraspores under laboratory conditions. The reproductive phenology of *A. armata* was previously assessed 35 years ago at this location, and since then, the average sea surface temperature along the northeast coast of the North Island has increased at a rate of 0.4 °C per decade. This study therefore provides the first temporally longitudinal analysis of potential climate driven shifts in reproductive phenology of a seaweed of emerging commercial importance.

Abstracts

Effects of light intensity on bromoform biosynthesis and gene expression in *Asparagopsis taxiformis*

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Managing light intensity in *Asparagopsis taxiformis* aquaculture is crucial for enhancing production of biomass and halogenated natural products, specifically bromoform. However, a comprehensive understanding of the genes involved in bromoform biosynthesis is required to explore the interplay between light, growth and bromoform production to direct culture management. Bromoform is synthesised by vanadium bromoperoxidases (vBPOs) but the influence of specific vBPOs on bromoform concentration in *A. taxiformis* is unclear. Here, we investigated the impact of light intensity on the filamentous sporophyte-stage of *A. taxiformis* to determine the relationship between gene expression and bromoform production. *A. taxiformis* (Lineage 6, Sunshine Coast, Australia) was cultured under five different light intensities for 14 days, in which the highest treatment of 173 μmol photons m^{-2} s^{-1} promoted both the highest growth rate (6.8% daily growth) and highest bromoform concentration (14.3 mg/g dry weight). We observed differential expression in genes relating to growth, energy metabolism and oxidative stress response, including photosynthesis-associated genes and other peroxidases. Three vBPO genes were characterised through comparative sequence and phylogenetic analyses, but no upregulation in expression was detected when comparing the highest light to the lowest light treatment. Although high light levels produced faster growing seaweed, with increased bromoform content, there was no clear relationship between a high bromoform concentration and expression of the vBPO genes. We discuss these results in the context of broader gene regulation of the vBPOs, as determined by q-PCR, and the potential involvement of other bromoform biosynthesis-associated genes in *A. taxiformis*.

Abstracts

Effects of light quality and intensity on the growth and bromoform content of *Asparagopsis taxiformis*

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Species of the red seaweed genus *Asparagopsis* are rich in halogenated bioactive compounds, particularly bromoform. Its use as a feed additive in ruminant livestock drastically decreases the animal's methane production, thereby reducing the industry's environmental impact. To address the high demand for *Asparagopsis* biomass, it is necessary to understand the culture conditions that promote higher growth rates and the concentration of the halogenated compounds. Here we evaluated how light quality and intensity affects the growth and bromoform content of the *Asparagopsis taxiformis* tetrasporophyte in indoor tumbling cultures at two biomass densities (0.5 and 2 g L^{-1}). We also assessed the effect of light intensity on the photosynthetic response by measuring oxygen evolution rates. We found that a combination of spectra that included intermediate wavelengths (485-630 nm) at a light intensity of at least 90 µmol quanta m^{-2} s^{-1} promoted the highest growth rates within the range of conditions tested, regardless of the biomass density. However, the lower saturating irradiances for photosynthesis (65.2 and 53.9 µmol quanta m^{-2} s^{-1} at densities of 0.5 and 2 g L^{-1}, respectively) and the development of contamination in the 90 µmol quanta m^2 s^{-1} treatment, suggests that long-term exposure to light intensities above 60 µmol quanta m^2 s^{-1} could be detrimental. Our results also show that managing light intensity (and exposure duration) can be used to promote the bromoform content of *A. taxiformis*. These results provide valuable information to optimise the production of biomass and bioactive compounds in *Asparagopsis* indoor tumbling cultures.

Abstracts

Patterns of expression in the sea: Biophysical influences on halogenated natural products in Asparagopsis

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There is growing interest in farming red seaweeds from the genus *Asparagopsis* due to their potential application as a feed supplement for ruminant livestock, to mitigate methane emissions from these animals, which accounts for a significant proportion of global greenhouse gas emissions. However, we understand very little about natural variation in biosynthesis of the bioactive compounds produced by *Asparagopsis* that have this important effect in ruminants. It has been well established that abiotic factors can affect the production of natural products in other seaweeds, however we do not understand how seasonal or experimental changes in temperature or other abiotic factors (e.g. light) affect the synthesis of bromoform in this seaweed. Furthermore, recent compelling evidence suggests that some microbes (or microbial functions) are essential for normal development, defence and even reproduction in seaweeds and that such associations can be similar amongst familial individuals. Although there are no examples of microbes influencing the biosynthesis of natural products by seaweeds, there are certainly examples of marine microbiomes influencing gene expression in their hosts. Understanding which conditions lead to enhanced biosynthesis in *Asparagopsis* and whether association with certain microorganisms can enhance biosynthesis in *Asparagopsis* will inform the development of an aquaculture industry for this species. We will present the results of a 12-month monitoring program measuring the concentration of bromoform in *Asparagopsis taxiformis* individuals in a natural population of this species and correlate this with physical, demographic and microbiological data.

Abstracts

Research to inform *Asparagopsis armata* cultivation in Tasmania

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Algae in the red algal genus *Asparagopsis* (Bonnemaisoniaceae) produce biologically active secondary metabolites which, when fed to ruminants, reduce methane production by up to 98%. Consequently, *Asparagopsis* has been highlighted as a significant opportunity for the seaweed aquaculture industry but cultivation methods to supply *Asparagopsis* are not well-developed. Here, we discuss recent findings on the reproduction, growth and bromoform production in *Asparagopsis armata* in Tasmania and highlight opportunities for enhancing *A. armata* cultivation. *A. armata* is common around Tasmania but shows large variation in abundance and bromoform concentrations among sites and times. Both gametophytes and tetrasporophytes of *A. armata* reproduce asexually via fragmentation and sexually via spores providing different options for cultivation of gametophytes (at-sea) and tetrasporophytes (on-land). For both stages, identifying the best propagule type and size appear important in optimising biomass and bromoform production. Despite rapid progress, there are still many knowledge gaps surrounding the cultivation of *A. armata* and future research directions will be discussed.

Abstracts

The biochemical composition of *Ulva* spp. upon harvest time and colour separation

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The green seaweed *Ulva* is a promising protein source for food production. Various factors can affect the biochemical composition, which can complicate the utilisation on a commercial scale, where a uniform biomass supply is advantageous. This study investigates the composition of *Ulva spp.* harvested in a Danish fjord in May, June and August 2021. The August harvest was furthermore divided into different colours (Light green, green and dark green/black) to explore a relation between colour and composition, which have not been documented so far. Dry matter (DM), crude protein (CP), fat, ash, and element composition were investigated. DM was highest in May and August (15%), whereas the June harvest was lower (7%). For the different colour fractions, DM increased with a darker colour. The CP and ash contents were highest in the dark biomass (15% and 34%, respectively) and concerning season variation, the May harvest showed the highest content (20% CP and 40% ash), which correlates with a predominantly dark colour. The ash content decreased with a lighter colour. The June harvest was mostly light green, corresponding with the lower CP content in the light green fraction from August (June 6% and light green 7% CP). Fat content ranged between 0.9-2.2% and a higher fat content was correlated with a lighter biomass colour. P and K was highest in the green fraction, whereas the darker biomass was higher in all other elements. This study shows that colour coding can be used as an indicator for the chemical composition.

Abstracts

Seaweed Solutions for Sustainable Aquaculture: nutritional profiling of Australian kelps

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Global demand for seaweed is increasing alongside the interest in sustainable aquaculture, stimulating industry investment in the production of seaweeds, particularly through integrated multitrophic aquaculture systems (IMTA). To meet future food demands, seaweed aquaculture must expand beyond Asia, into other regions with high production potential and where novel native and/or endemic seaweeds can lead to a diversification of the seaweed farming sector. High diversity of endemic seaweeds and relatively clean coastal waters suggests Australia could be a key player in seaweed production for high quality food/feed and pharma/nutraceutical applications, but optimization of culture conditions and nutritional profiling of Australian species is still in its infancy. The Seaweed Solutions for Sustainable Aquaculture project (www.seaweedsolutions-crc.com/) is attempting to address these knowledge gaps for Australian laminarian kelps cultivated alongside salmonid and mussel farms in Tasmanian coastal waters. As part of the research conducted within the project, this study investigated the nutritional profile of wild harvested and cultivated Australian kelps (*Macrocystis pyrifera*, *Ecklonia radiata* and *Lessonia corrugata*) focusing on proximate composition, fatty acids, minerals and metals, elemental analyses, pigments, and antioxidants. The results will be discussed considering the overall composition as well as the factors that contributed to variability within, and the implications for the potential commercialization of these species, including in co-culture/IMTA systems.

Abstracts

Cultivation of red and green seaweed in Natural saline lagoon aera: impact of salinity and nutrient condition on chemical composition

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LOCAL is a French project dedicated to the cultivation of *Ulva sp., Chaetomorpha sp., Cladophora sp. and Gracilaria sp.* on natural saline lagoon located in south of France. The development of seaweed aquaculture in salt marshes and the salinity stress induced on the cultivated species could lead to new sustainable sourcing for various applications improving quality and productivity aspects.

The main objective was to evaluate growth and biomass yield, as well as the impact of environmental factors such as salinity, nutrients concentrations, turbidity on chemical composition of each species. Besides, the chemical characterisation from the 2-years seasonality study (2020 and 2021) focused on neutral carbohydrates, uronic acids sugars, amino acids and minerals profiles. Comparison with wild feedstock was highlighted, showing interesting composition potentially related to salinity stress. Then, some extraction protocols were applied to produce polysaccharides and amino acids extracts from cultivated biomasses. The project unveils opportunities and provides tools for the development of innovative sourcing from saline environment in south of France. Main stress response will be presented including metabolites profile in those tailored biomasses. The production of extract will be also benchmarked with an evaluation of potential applications in several markets (cosmetics, feed, food, etc.). Furthermore, the impact of environmental conditions on rheological properties of agar extracted from two *Gracilaria* sp. was assessed, leading to interesting potential applications for the texturizing market.

Abstracts

Cultivating seaweeds in food production process waters - a circular approach to producing blue proteins

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There is an increasing demand for sustainably produced protein-rich and nutritious food. Seaweeds are promising protein sources for the future if their protein content can be optimized. Cultivation of seaweeds in integration with fish farms has received much attention lately, but using other nutrient-rich process waters as cultivation media for seaweeds has rarely been studied. We explore the possibility for an industrial symbiosis between food production processing industries and seaweed cultivation. From initial experiments we show that both growth and crude protein content of the green seaweeds *Ulva fenestrata, Ulva intestinalis* and *Chaetomorpha linum* were significantly increased when cultivated in a wide range of different process waters, ranging from the production of herring, shrimp, salmon and oat. When upscaling the experiment with *U. fenestrata* and two selected herring production process waters, we managed to increase the biomass yield four to six times and crude protein content three times (> 30 % dry weight vs. 10 % dry weight) compared to *U. fenestrata* cultivated in seawater. The herring production process waters also significantly increased all essential amino acids in the seaweed biomass. Furthermore, the heavy metal content (arsenic, mercury, lead, and cadmium) in the biomass was well below the maximum allowed levels in foodstuff set by the European Commission. Combined, the results show that there is great potential for the symbiosis between the cultivation of seaweeds in food production process waters to produce sustainable proteins for the growing world population.

Abstracts

Solubilisation of waste biomass from *Ecklonia maxima* processing

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South Africa's bourgeoning seaweed concentrate industry derives an agricultural stimulant from *Ecklonia maxima* through an extraction process that produces a significant amount of waste biomass (mostly comprised of the solid cell components), a stream rich in structural biomaterials such as cellulose, fucoidans and alginate. Currently, this waste is discarded into the municipal waste system, costing the company money as well as losing a significant quantity of valuable materials. Hydrolysis of structural carbohydrates within the waste would serve to solubilise the solid into a liquid which might be applied in agriculture, while yielding valuable bioactive oligosaccharide products. The current state of the art has demonstrated alginate hydrolysis typically using aggressive acid treatments at high temperatures or using expensive (and limited availability) alginate lyase enzymes. These conditions are not often feasible in post-hoc industrial processing – where companies are loath to invest in high-temperature or high-pressure reaction vessels, or expensive reagents. Within the limitations of industrial scale waste valorisation, the current study investigated ambient temperature chemical hydrolysis of both pure alginate and waste biomass. Sulphuric, formic, and acetic acids at various concentrations either alone or in combination with hydrogen peroxide were tested as digesting agents on both pure alginic acid and industrial waste, at ambient temperature. Degradation was quantified using a total solubilised carbohydrate methodology. Results surprisingly indicated improved degradation using organic acids over mineral acids, while the inclusion of hydrogen peroxide significantly improved solubilisation. Future work will focus on identifying and quantifying the oligomers produced as a function of reaction time.

Abstracts

Climate change resilience of *Laminaria farlowii*, a deep-water kelp from Southern and Central California

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Laminaria farlowii is of interest as a novel species for aquaculture in Southern California. Its thermal biology and climate change resilience are not well known. Wild populations of *L. farlowii* live primarily below the seasonal thermocline but individuals have been successfully cultivated in near surface conditions of light intensity and temperature. We examined the thermal biology of gametophytes and sporophytes of *L. farlowii*. We grew gametophytes and juvenile sporophytes across gradients of temperatures (9-20°C) and light intensity (20-80 µmol photons $m^{-2} s^{-1}$), finding growth rates were saturated by all light intensities tested and sensitive to temperature. Optimal growth temperatures were 13°C for gametophytes and 15°C for sporophytes. In a separate experiment, sporophytes were exposed to thermal regimes differing in mean temperature (10-20°C) and thermal variability, under a photoperiod chosen to induce sorus formation. Growth rates were not significantly different from 14-18°C but sori were formed only at mean temperature of 15°C. We evaluated the ability of *L. farlowii* sporophytes to survive brief simulated marine heat waves (upshock of 3°C for 3 or 5 days), finding no detectable effect on growth rate after 4 days of recovery despite decreased photosynthetic electron transport rates after both 3 and 5-day simulated marine heatwave treatments. Comparing that thermal tolerance to the annual sea surface temperature in Santa Barbara, California from 2007 to 2021, we predict that *L. farlowii* could be actively growing near the surface 75% of the time and survive brief marine heat waves.

Abstracts

Effects of Ocean Acidification and Irradiance on Growth and Recruitment of early successional Coralline Communities

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Coralline algae play key ecological roles in costal ecosystems globally and are known to occur down to the limits of the photic zone. Despite their demonstrated susceptibility to ocean acidification (OA) and importance in low light environments, there is limited understanding of the interplay between irradiance and OA on growth and reproduction of this important group. Early successional coralline communities (established in the field) were subjected to a gradient of daily light dose (0.35, 0.17 and 0.1 mol m^{-2} d^{-1}) - a range based on in situ measurements - and 2 pH levels (present-day pH 8.03, OA pH 7.65) in a 212-day experiment to test the sensitivity these communities and subsequent recruitment to OA in low light environments.

Lowered seawater pH reduced growth of the parental coralline communities by > 60% across the light gradient, with a parabolic growth response to irradiance and no interactive effects. In contrast, the OA-driven reduction in new recruitment (56%) was amplified under reduced light with recruitment near zero in the lowest light treatment.

The present study shows that irradiance may play an important role in determining the outcomes of OA on coralline communities and for the first time, shows the increased vulnerability of coralline recruitment to OA under low light. Coralline algae are known to be the

deepest growing macroalgal group. Thus, OA could affect coralline communities in these low light zones disproportionately and therefore also alter depth distribution.

Abstracts

Exploring variable kelp resistance and resilience to climate-driven disturbances with Kelpwatch.org, a visualization web-tool.

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Giant kelp and bull kelp forests are increasingly at risk from a series of stressors including marine heatwave events and herbivore outbreaks. Understanding the spatial and temporal dynamics of kelp loss and recovery is important for implementing strategic restoration and management efforts. The floating canopy of these kelps is well-suited to study via satellite imagery from Landsat, which provides high temporal and moderate spatial resolution data of floating kelp canopy. As the world's largest record of kelp canopy dynamics in both time and space, Landsat imagery offers users the rare opportunity to attempt to distinguish the impacts of climate change on kelp abundance, which is an important management challenge that requires long-term (>30 years) time series data at large spatial scales in order to separate climate-related trends from other sources of variability. However, the size and complexity of the satellite image dataset has made ecological analysis difficult for scientists and managers. To increase the accessibility of this rich dataset, our team created Kelpwatch.org, a web-based visualization and analysis tool. Here, we demonstrate how Kelpwatch.org can be used to analyze long-term trends in kelp canopy across regions, quantify spatial variability in the response to record-breaking marine heatwave events, and provide a local analysis of kelp canopy status around the Monterey Peninsula, California USA. Kelpwatch.org provides near real-time spatial data on a platform that makes complex earth observation data actionable for scientists and managers, which can help identify areas for strategic and data-driven kelp research, monitoring, and management efforts.

Abstracts

Carbon dynamics in a macroalgal habitat of Korea

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Ocean biological activity tends to shift the dynamics of surface pCO_2 from effects primarily controlled by changes in the sea surface temperature (thermodynamic cause). The biological activity in a macroalgal habitat of coastal Korea contributed 4.4 g C m^{-2} $month^{-1}$ of the net C uptake during the growing period (the cooling period, September-May), and changed the thermodynamic-induced seasonal dynamics such that the air−sea equilibrium of pCO_2 was impeded by the increased magnitude of disequilibrium. The surface pCO_2 dynamics during the cooling period was significantly affected by the seasonal decrease in temperature and the proliferation of macroalgae, while the dynamics during the warming period (the stagnant period, June-August) closely followed that predicted from the thermodynamic drivers (i.e., changes in sea surface temperature). In contrast to the phytoplankton-dominated off-shore waters, in which phytoplankton populations are typically large in spring and summer, the impact of coastal water macroalgae on surface pCO_2 dynamics was most pronounced during the cooling period, when the magnitude of pCO_2 change was as much as twice that resulting from thermal-driven changes. Moreover, the distinctive features of the nearshore vegetated habitat—large seasonal temperature extremes (~18°C), massive anthropogenic nutrient inputs, and active macroalgal metabolism—intensified the seasonal decoupling of seawater and air pCO_2 dynamics.

Abstracts

How spatial resolution modify the seaweed covers estimation? Comparative study in Brittany using vegetation indices

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Temperate rocky shores are highly diverse and dynamic ecosystems threatened by anthropogenic and climate change driven pressures. The primary producers developing are mainly canopy-forming Phaeophyceae, commonly monitored to detect ecological changes. As remote sensing is increasingly *used* to better understand the functioning of coastal ecosystems, this work aimed at comparing *in situ* data to vegetation indices defined through two resolution remote imagery approaches, satellite (50 cm) and UAV (2 cm) on two sites of Brittany (NW France). Covers of dominating seaweeds were characterized in the field and by remote sensing in 24 sampling spots (2.7 m^2 each) according to 4 vertically distributed bathymetric levels dominated by Phaeophyceae: 1- Pelvetia canaliculata and *Fucus spiralis* (high shore), 2- *Ascophyllum nodosum* (mid shore), 3- *Fucus serratus* (low shore) and 4- *Himanthalia elongata* and *Laminaria digitata* (sublittoral fringe). Three vegetation indices were determined from imagery: Normalized Difference Vegetation Index (NDVI), Vegetation Cover Index (VCI) and Pigment Index (IP). *In situ* covers were significantly different from remote sensing indices in the high shore, but were otherwise similar in the subsequent bathymetric levels. Both VCI and IP values were unaffected by the resolution. On the contrary, NDVI calculation was dissimilar according to the resolution considered and whatever the bathymetric level. To conclude, the three vegetation indices offered coherent results suitable for the study of macroalgal-dominated habitats, fluctuating logically according to the bathymetric level. Even if low resolution seems acceptable to roughly describe seaweed covers, a high resolution appeared yet needed when fully monitoring macroalgal communities' structure.

Abstracts

Mapping *Sargassum* meadow for estimation of biomass using side scan sonar

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Sargassum meadows play important roles in coastal ecosystems, CO_2 fixing, and others. Estimation of their biomass helps conservation of meadows and estimation of the amount of fixed CO_2 for blue carbon projects. Most sonars are inefficient in shallow waters because their swaths are limited by water depth. Side scan sonar (SSS) creates a detailed image of the bottom efficiently even in shallow waters transmitting wide beams.

We towed SSS from the ship's side and scanned the meadow of *Sargassum horneri* at a small beach in Otsuchi Bay on the Sanriku Coast of Japan during the growing season of 2022. For the truthing, we surveyed with the underwater camera and Single beam echo sounder (SBES) to compare with SSS data.

SSS scanned the sea floor of the beach to detect seaweed echoes. The beach consists of sandy area and rocky shore. The seaweeds were discriminated from the sand and rocks by their acoustic shadows, and we pinpointed their locations, although the background reflectance strength and pattern were different between two areas. To estimate the canopy heights, we measured the acoustic shadow lengths of the seaweeds. However, the shadows of the seaweeds which located very near to the sonar are too short to measure. Therefore, we developed a new method to measure their heights from acoustic reflections instead.

Our study demonstrated the effectiveness of side scan sonar for mapping *Sargassum* meadows in shallow waters and estimating their canopy heights with novel method, which lead to precise biomass estimation.

Abstracts

Current trends and future prospects of seaweed cultivation and breeding in Korea

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Korea has a well-established seaweed industry ranked 3rd among the world's seaweed-producing countries and is the world's leader in *Pyropia* exports. The impetus for the seaweed industry's growth in Korea stems from a combination of a national preference for seaweed cultivation and significant investment to industry capabilities and technologies. In 2019, Korea produced 1,812,765 tons of seaweed out of a worldwide production of 34,568,073 tons (wet wt.). Although *Saccharina japonica* accounts for the largest production biomass (662,557 tons), *Pyropia* is the most economically important seaweed species in Korea, accounting for 66% of the total seaweed production value. In recent years, industry growth has been achieved through the adoption of technologies that lead to increased productivity. Significant work has gone into developing more productive strains of key seaweed species, and in 2012 the Korean government began to certify seaweed varieties. To date, 28 seaweed cultivars have been registered including 22 *Pyropia*, 5 *Undaria* and 1 *Saccharina* (APVC 2022). The direction of seaweed breeding for circular economy in Korea is to develop varieties that increase economic feasibility, such as high temperature and disease-resistant, and functional varieties of *Pyropia*, and to secure competitiveness of other industries such as restoring coastal environments and securing stable food sources of abalone industry of *Saccharina* and *Undaria*.

Abstracts

Seaweed aquaculture in Aotearoa New Zealand – from bucket science to implementation

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Seaweed aquaculture is an emerging industry in Aotearoa New Zealand, with interest and support from both Government and Industry steadily increasing over the past five years. Here, I will provide an overview of the work of my research team at the University of Waikato to provide a foundation for building and supporting this emerging industry with applied research anchored in a fundamental understanding of biology, ecology, and chemistry. As the most advanced examples, I will discuss the aquaculture of *Ulva* (sea lettuce) and *Ecklonia radiata* (common kelp), and our journey from petri dishes to bucket science to implementation. I will touch upon some of the drivers behind the renewed interest for seaweed aquaculture in Aotearoa New Zealand, and share some of the hurdles and bottlenecks as well as the key facilitators underpinning our progress.

Global and local marine agronomical trends: developmental facts or only good desires?

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Globally seaweed production is undergoing a rapid expansion at a time of accelerating climate change, hence raising new challenges for producers and the environment. Currently, the seaweed industry supports the livelihood of millions of small-scale farmers and processors, including women, demonstrating it potential to drive the development of many coastal areas worldwide. A relevant proportion of seaweed production goes to human consumption, which is part of the blue food supply chain, especially in Asian countries. A less significant proportion of the global seaweed production has been driven by a growing commercial demand for higher value seaweed-derived products, such as cosmetics, pharmaceuticals, including agarose, but also by less valuable products but with a larger market such as seaweed-based agronomic biostimulants and biomaterials among other uses which offer to open new market opportunities. However, seaweed production has several challenges related to their global expansion such as the consolidation of new market opportunities, productivity, sustainability, installation of proper and global biosecurity standards, and risk management related to diseases and grazing outbreaks, offshore cultivation conditions, and the valorization of the local environmental benefits associated with coastal eutrophication and ocean acidification mitigation. In relation to these challenges, R&D and novel global and country level policies are required to make seaweed aquaculture a reality beyond Asian countries. Financial Support: FONDECYT (1221161), CeBiB (FB-0001), MASH (NCN2021_033).

Abstracts

Macrocystis pyrifera cultivation at scale: how the industry can think big, but stay focused

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One issue facing the seaweed industry is how to “scale”. Kelp Blue was founded in 2020 with this specific goal in mind. Scaling has not only to do with increasing efficiency of the various components of seaweed farming and processing but it’s also essential to have the correct mindset while staying focused on achieving the smaller milestones that prove that progress is being made, and ongoing funding and investment is secured. Getting the balance right to ensure continuity requires this balance.

We will be sharing our learnings on how to balance the collective vision (for the industry) while also focusing on operational success to keep projects funded and progressing with a specific focus on Macrocystis pyrifera and the nuances of this particular species.

Kelp Blue learnings to date about setting up a seaweed farm, the good, the bad and the ugly

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Hortimare supports new and experienced seaweed farmers with transparent and committed collaboration- both principles are cornerstones of being able to scale the industry—not one organization can do it alone. Kelp Blue is an example of an ambitious and resourceful seaweed start-up. Hortimare supports in achieving the scaling and production goals.

We do this by sharing our combined seaweed cultivation experience that spans decades in Hatchery and technical, production, farming strategy and hands-on field assistance. Together we've experienced both highs and lows. In this talk I will discuss some of the strategies and learnings that Hortimare implements when supporting farmers, using Kelp Blues operations in Namibia as an example.

Moving beyond the ocean: commercialisation of seaweed products for agriculture (and other industries) and how it contributes to the wider shift to sustainability

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Ensuring a broad marketplace for seaweed and seaweed related products requires a wider market development effort beyond a focus on the oceans. Shifting the focus to the end applications and the positive impact they have on the wider shift to sustainability can have outsized effects on the ability to market and commercialise seaweed derived products. We'll be sharing insights into the global market potential for non-food related components extracted from kelp/ macrocystis, wider positioning/messaging strategies and the new market potential given innovations in related industries able to absorb seaweed derived products.

Abstracts

Biostimulants global market overview and trends/predictions

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New regulations are increasing demands for seaweed-based biostimulants. New start-ups are entering the market with new extraction methods, hoping to displace chemical fertilisers and compete with larger established agricultural players. Increased commodity process are also accelerating the growth of the biostimulants marketplace, but how long can this go on if there is not enough supply to meet the growing demand. We will be discussing market-size, impact of new players on the global demand and predictions for the coming 4 years.

Abstracts

Developing production systems for offshore kelp mariculture in SE Australia

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With the participation of:

Blue Economy CRC

Southern Ocean Carbon Company

Huon Aquaculture

Climate Foundation

Deloitte

BMT Group

Australian Maritime College

Department of Natural Resources & Environment, State of Tasmania

CSIRO (Commonwealth Scientific & Industrial Research Organisation)

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The talk outlines a large project (AU$3.24M) intended to set foundations for offshore kelp mariculture in SE Australia. The overall goal is to develop and test a production system for offshore kelp mariculture that is scalable, economically viable, attracts strong social licence, and supported by regulatory frameworks. Several distinct elements need to be integrated. The engineering component includes design and trial of a modular farm layout, and processes and infrastructure for outplanting and harvest. Another important engineering element addresses the challenge that surface waters in SE Australia contain insufficient nitrogen for commercial kelp farming. We will grow kelp adjacent to salmon pens as a source of nitrogen (ammonia), and in deep water (≥100 m) where there is elevated nitrogen (nitrate) in water beneath the farm. The alternatives of using wave energy to pump nutrient-rich water from depth to irrigate kelp at the surface, and diurnal depth-cycling in which kelp are lowered to the nutrient rich water at depth during the night, will be compared. Monitoring will focus on physical loads on the infrastructure as a function of sea state and stage of development of the crop, the production performance of the kelp, and biotic and abiotic characteristics of the environment at the farm site and adjacent 'control' sites. Towards an appropriate regulatory framework, current policy and legislation will be analysed, regulatory arrangements for seaweed production in other countries reviewed, and engagement of industry members and policy makers on current policy and future options canvassed. Economic assessment includes both conventional economic viability assessment and natural capital accounting.

A Collaborative Platform for Growth: The GreenWave Regenerative Ocean Farming Hub

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In April 2022, GreenWave launched the Regenerative Ocean Farming Hub: an open-source platform designed to train, support, and connect seaweed farmers around the world. In this free-to-anyone digital space, beginning kelp farmers can find curricula and interactive tools to support them throughout planning, permitting, designing, and deploying their farms; as well as how-to videos and lessons on outplanting, monitoring, harvesting, and selling their first commercial crops. The real magic, though, is in the Community: a farmer-driven forum designed to encourage collaboration and knowledge exchange, where beginning and advanced farmers alike can ask questions of one another, forge connections, and share innovations and updates coming off their farms. In this presentation, we'll give a tour of the Hub, and share examples of how experienced farmers, scientists and industry experts have used the community space to directly connect with and support active ocean farmers. We'll make the case that collaboration — more than competition — will propel the industry forward, and invite members of the international seaweed community to join in the movement.

Scaling of seaweed cultivation: site selection and (bio) technical solutions for cost-effective farm operations

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Over the last decade seaweed farming has been developing in Europe, the America's and Australia / New Zealand. However compared to Asia the acreages are still very small and the produced biomass too little to attract large industries. Scaling of the seaweed farms to a unit production of around 10.000 ton wet weight, would reduce the cost price and make seaweed as a raw material much more interesting for industrial applications.

Several projects have been initiated to develop seaweed cultivation rigs which allow moving further offshore. Most elementary however is the farm site selection. In this talk we review recent scientific research work and complement this with our team experience. The site selection criteria will be discussed, ranging from oceanographic aspects and ecosystem impacts to nutrient supply. Important selection criteria, such as bio-fouling and nutrient supply will be discussed with respect to cultivation approach and yield. Solutions for cost effective, safe and robust offshore seaweed farming will be touched.

Exploring the Kelp Farm Design Tool: an interactive planning tool on GreenWave's Ocean Farming Hub

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Launched in April 2022, GreenWave's Regenerative Ocean Farming Hub is a free, online resource designed to provide seed-to-sale support for both emerging and experienced ocean farmers and hatchery technicians. Already having drawn over 2,200 users across 88 countries and 47 U.S. states to date, the Hub Courses, Tools, and Community make GreenWave's training and support offerings and community knowledge-sharing accessible to a significantly wider audience, helping the industry scale and problem-solve more rapidly and efficiently. Using the Hub's Kelp Farm Design Tool, aspiring farmers can easily navigate common startup pain points by generating basic farm designs, gear lists, budgets, and U.S. state-specific permitting language, based on the location and characteristics of their sites. With this Tool, users can visualize how certain site factors influence farm design, assess financial viability early on in the process, and download permit-ready design descriptions to support effective communication with regional regulators. This presentation will address the models, assumptions, and safety factors built into the Kelp Farm Design Tool; and will explore possibilities for expanding its utility to new regions, design types, and species.

Abstracts

Upscaling open ocean kelp cultivation in the Atlantic Ocean and offering an economic performance study of the operation

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The EU Horizon 2020 funded project AquaVitae has, among other things, investigated how to upscale open ocean kelp cultivation. The company Ocean Rainforest Sp/F (ORF) has been the key industrial partner to lead this work. ORF cultivate kelp in the Faroe Islands in high wave and exposed areas using a well-tested macroalgal cultivation rig (MACR). The company's activities span the entire supply chain from producing seeding material to cultivating at sea to processing into storage stable products for the food and feed market. For the past years, ORF has been cultivating at small scale (<300 tonnes wet weight/year) but is expanding its production. The environment around the Faroe Islands has a stable sea temperature and allows for multiple partial harvesting of *Saccharina latissima* with up to six harvests without re-seeding of the grow lines. This has the potential to reduce production costs significantly. However, upscaling of production and cost-efficient logistics are required to exploit the seaweed biomass. AquaVitae has addressed some of these challenges, partly by further developing the state-of-the-art cultivation technics and processing facilities, and partly by investigating the possibilities to expand seaweed production in the Atlantic Ocean. Finally, AquaVitae examined the economic feasibility for a sound operation of the MACR for producing *S. latissima.* This will be analyzed considering different production setups to optimize the economic efficiency of this cultivation technic.

Can morphology or photobiology explain the farming success of *Macrocystis* multiple frond morphotype?

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The Giant kelp *Macrocystis pyrifera* has high physiological and morphological plasticity, which explains its high productivity and adaptability to different coastal environments. Growing this kelp under controlled conditions can lead to achieving sporophytes with different morphotypes, *i.e.,* few (≤2) and multiple (≥3) fronds morphotypes. We also know the origin of the population and its genetics seem relevant to determine the growth success under near optimum environmental conditions. By setting up a suspended farming system in Southern Chile, for over 90 days, with kelp recruits obtained under laboratory-controlled conditions (10-15 cm length), we have demonstrated that the multiple frond sporophytes show higher productivity. Juvenile sporophyte laboratory experiments, carried out with both morphotypes obtained from two genetically distinct populations (and their outcross), were performed under optimal culture conditions. Photosynthetic parameters using Pulse Amplitude Modulation (PAM) Fluorometry and photosynthetic pigments could not explain the differences in growth between different genotypes and sporophyte morphology. Surface volume ratio (S/V) showed, only in some cases, a trend to increase in multiple fronds sporophytes explaining their higher growth rate. Nutrient (N) limitation experiments showed that under limiting conditions and under high nutrient availability multiple fronds can also show a higher growth rate. We discuss the implications of these findings for aquaculture practices.
Financed by: FONDECYT(ANID) 1180647 & 122116.

Abstracts

Patterns of growth and productivity in *Ascophyllum nodosum* populations from a wide geographical range

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Ascophyllum nodosum (L.) Le Jolis (Fucales, Fucaceae) is an intertidal brown alga that is commercially harvested in several countries. Productivity estimates are sparse and for the most parts are calculated based on apical growth only. We carried out a broad-scale survey at twenty-three sites from both sides of the North Atlantic to measure growth, reproductive output, loss of tissue over winter, and productivity of *A. nodosum*. We assessed the length and mass of successive internodal segments and established that, contrary to previous findings, internodal segments continue accumulating mass for one to five years and increase in length for one to three years at most sites. Segments can almost triple their mass during their second year and more than double their length. In some populations, annual growth in older parts of the frond can represent as much as 36% of the biomass and be greater than the growth at the tip of the frond. When accounting for the growth at the tip and in older parts of the fronds, total annual growth can represent up to 55% of the frond biomass. These results indicate that previous productivity and growth estimates for *A. nodosum* based on apical growth alone greatly underestimated the productivity of the species and its role in coastal carbon cycling. Furthermore, because they grow over a period of several years, internodal segments should not be used to infer past environmental conditions or to reconstruct growth patterns over time.

Mannitol as a Resource for the Growth and Reproduction of *Sargassum siliquastrum* (Turn.) Ag.

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The seasonal and individual variations (between holdfast, basal, middle, top blade regions and receptacles) of mannitol in *Sargassum siliquastrum* collected monthly over a 30 month period were investigated using HPLC. Seasonal variation of its mannitol content ranged from about 1 to 17% of its dry weight. Mannitol content increased with growth and peaked during the active growing stage in September to October (10.81 ± 4.87 to 13.17 ± 5.60 g mannitol/ 100g dry seaweed). A drop in mannitol content was recorded only at the start of the reproductive period in December and remained stable thereafter. Dramatic decrease in mannitol concentration occurred after the reproductive period and a small increase in mannitol content was identified in the middle of the slow growth stage in April to (5.69 ± 2.11 to 17.87 ± 7.46 g mannitol/ 100g dry seaweed), suggesting that the surplus produced during the slow growth period may be used to maintain the perennial holdfast or to develop new shoots for the next season. On an individual level, more mature basal part of the plant (i.e. holdfast and basal blade region) contained higher levels of mannitol when compared with the younger middle and top blade regions. Receptacles of *S. siliquastrum* displayed the lowest mannitol content, which appeared to match its low photosynthetic activity. The disproportionally high level of mannitol in the photosynthetically less active holdfast suggested that mannitol may be diffused from the basal blades down to the holdfast to be utilized for the development and elongation of new shoots.

Unravelling the secret life of MAD gametophytes

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The family of Laminariaceae have a heteromorphic lifecycle that alternates between haploid gametophytes and diploid sporophytes. In contrast to the macroscopic sporophytes, the haploid gametophytes are of microscopic nature and delayed gametophytes are especially understudied. Delayed gametophytes are gametophytes that have been growing vegetatively, as undifferentiated filamentous cells, for prolonged periods of time, without sexual reproduction. Gametophytes that delay their reproduction for more than a year, transgress any seasonally induced reproduction and are called multiannual delayed (MAD) gametophytes. Studies revolving around MAD gametophytes are gaining more and more attention since they play a key role in large scale kelp aquaculture. Novel insights from these studies could not only progress the utilization of MAD gametophytes in kelp aquaculture, they can also generate key insights into the role of MAD gametophytes in their natural environment. An environment which up until now is still poorly described. For example, there seems to be a strong inverse correlation between the density of female gametophytes in a culture and the reproductive success of this culture. What is the mechanism behind this inverse correlation, and how does this translate to the natural environment of MAD gametophytes? During this presentation we will delve deeper into this secret life of MAD gametophytes, their (a)biotic lifecycle controls and their interaction with the natural environment.

Abstracts

Thermal tolerance of the giant kelp (*Macrocystis pyrifera*)

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The giant kelp, *Macrocystis pyrifera*, is sensitive to warming and marine heatwaves but little is known about how increased sea surface temperature (SST) and heatwave events will influence microscopic life stages of this species. The main objective of this work was to determine the thermal threshold of microscopic haploid stages of *M. pyrifera* and identify whether the differences in populations' susceptibility to warming in New Zealand is reflected in genetic differences. Investigation on the effects of increasing temperature on sporogenesis was conducted on cultured stocks of *M. pyrifera* from a population in Otago, New Zealand. Sporulation was carried out across 10 temperature treatments from 9.5 to 26.2 °C ± 0.2 °C at approximately 2 °C intervals. Results from this experiment indicate that spore release was positively correlated with increasing temperature. Gametophytes of *M. pyrifera* from six sites in three regions at different latitudes across the South Island of New Zealand were exposed to nine temperature levels from 10.5 to 23.8 °C for a duration of twenty days. This experiment was conducted to determine the effects of elevated temperature and the effect of population location on gametophytic development. The thermal threshold for successful fertilisation was between 18.8 – 20.2 °C for the southern (coolest annual SST) population and 21.8 – 23.6 °C for the mid-latitude and northern (warmest annual SST) populations. In addition, over 30% of gametophytes survived under the maximum treatment temperature of 23.6 °C, suggesting a higher upper thermal threshold for this haploid stage.

Abstracts

Farms and forests: evaluating the biodiversity benefits of kelp aquaculture

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The biodiversity benefits of kelp aquaculture and afforestation are increasingly acclaimed as the industry continues to grow and develop globally. However, whether farmed kelp can provide this ecosystem service remains unclear. Using peer-reviewed literature, we evaluated whether kelp farms benefit biodiversity, and identified only 23 studies that discussed the effects of kelp aquaculture on biodiversity, half of which were broad reviews that assessed the concept of 'biodiversity' peripherally (e.g. did not focus on specific responses or taxa). There is also a general lack of experimental research on the topic. Evidence suggests that kelp farms can create habitat via changes to the local environment, particularly through the provision of structure and changed nutrient cycling. While this can lead to increased abundance and diversity among certain taxa (e.g. fouling organisms), it seems that kelp farms typically create novel habitats that support distinct communities not equivalent to natural kelp forests. Moreover, the potential for kelp farms to support biodiversity depends on a range of operational factors, many of which may be at odds with farming objectives that require the harvest and removal of the habitat that farms provide. While more work needs to be done to address the complexity of comparisons between kelp farms and forests, especially at appropriate experimental scales, it currently seems unlikely that kelp farms will act as kelp forests and deliver meaningful biodiversity outcomes. We should instead recognise farms for providing their own valuable services and support restoration and conservation practices of kelp forests to pursue biodiversity outcomes.

Abstracts

Where does all the seaweed carbon go?

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Demonstrating evidence of seaweed carbon sequestration has been the key challenge in incorporating seaweed into blue carbon (BC) inventories since the fate of seaweed carbon is largely unknown. We investigated the seaweed carbon fingerprint in marine sediments collected from 112 near-shore sites across seven biogeographical units (biounits) in southwestern Victoria, Australia using an environmental DNA (eDNA) approach. To understand the environmental drivers of seaweed transport and deposition, we assessed the effects of oceanographic parameters on the richness and relative abundance of seaweed taxa identified, and organic carbon preserved, in the sediments using generalized additive models (GAMs). A total of 67 macroalgal taxa (15 Phaeophyceae, 38 Rhodophyta, and 14 Chlorophyta) were detected in sediments from >91% of sampling sites. Modelling revealed the interaction of oceanographic parameters drove the diversity of macroalgae deposited in the sediments, and the strong effects of environmental parameters on potential exportation of coastal organic carbon sources, such as seaweed, towards the ocean. There were significant differences in the occurrence of taxa among biounits, in which 3 Chlorophyta, 7 Phaeophyceae, and 6 Rhodophyta taxa contributed to 70% of the variability in taxa among biounits. Caulerpa longifolia and a group of Phaeophyceaen taxa (assigned as Phaeophyceae due to database limitations) appear to be the most common taxa detected across biounits and contributed most to the similarity within each biounit. Overall, our findings have confirmed that macroalgal biomass is exported to and deposited in near-shore sediments. The high resolution in taxonomic identification obtained allows understanding of the patterns of macroalgal diversity and the key taxa preserved within the sediments, from which we can begin to understand the important macroalgal species with high recalcitrance that may contribute significantly to carbon sequestration.

Abstracts

Kelp dissolved organic carbon release is variable, passive, and decoupled from photosynthetically active radiation

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Macroalgae are foundational to many Indigenous social-ecological systems, and their production of dissolved organic carbon (DOC) serves various biogeochemical roles, potentially including Blue Carbon sequestration. However, data on the mechanisms of passive and active DOC diffusion, including the role of photosynthetically active radiation (PAR), are contradictory. For this experiment, DOC release rates from the kelp *Saccharina japonica* var. *religiosa* from Oshoro Bay, Hokkaido, Japan were investigated between January 2020 and July 2021. Up to six kelp individuals were divided between a low and high PAR treatment (200 and 400 μmol photons PAR m^{-2} s^{-1}) and incubated ex situ for up to 7 days, with twice-daily sampling according to a light/dark timer. There were no significant differences between the low and high PAR treatment results or the day and night release rates, with DOC accumulation largely linear throughout incubation. In addition, biomass was a poor predictor of DOC release rates, variability was high between individual kelp, and intra-annual variability was significant. These findings support the theory of passive overactive DOC diffusion. They also indicate that individual and seasonal variations should be accounted for in Blue Carbon estimates, and that biomass and primary production are unreliable predictors of kelp DOC release. Moreover, the relationship between variable passive diffusion and individual condition, growth stage, or season, means DOC release could serve as a proxy for biological or ecological health. Therefore, understanding macroalgal DOC variability may be useful to Indigenous coastal managers in terms of ecosystem health and Blue Carbon funding.

Abstracts

Brown algae inject fucoidan carbon into the ocean

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Brown algae annually convert gigatons of carbon dioxide into carbohydrates, including the complex extracellular matrix polysaccharide fucoidan. Fucoidan sequesters brown algal carbon due to its persistence in the marine environment. The lack of techniques to identify and quantify complex polysaccharides in seawater has impeded accounting for fucoidan carbon in the ocean. We adapted the techniques of anion exchange chromatography, enzyme-linked immunosorbent assay and biocatalytic enzyme-based assay for detection and quantification of fucoidan in seawater. They revealed that fucoidan constitutes up to half of brown algal exudates, a considerable fraction of primary production. *Fucus vesiculosus* in the Baltic Sea secreted 0.3% of their biomass as fucoidan per day. Dissolved fucoidan concentrations in seawater adjacent to algae reached up to 0.48 mg L-1. *F. vesiculosus* secreted fucoidan at a rate of 28-40 mg C kg-1 h-1, accounting for 44-50% of all exuded dissolved organic carbon. Our most recent results indicate that both Laminariales and Fucales enrich the surrounding seawater with fucoidan, which shows little no degradation over weeks. Composed only of carbon, oxygen, hydrogen and sulfur, fucoidan secretion does not consume nutrients enabling carbon sequestration independent of algal growth. Extrapolated over a year, the algae sequester more carbon into secreted fucoidan than their biomass. The global utility of fucoidan secretion is an alternative pathway for carbon dioxide removal by brown algae without the need to harvest or bury algal biomass.

Estimation of CO2 sequestration potential by population- and community-level metabolism of artificial seaweed beds

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As concern about the climate crisis increases, interest in the primary production of marine ecosystems for climate change mitigation is increasing. Recently, efforts aimed at the artificial transplantation of canopy-forming seaweed have been made to increase coastal productivity. This has been proposed as a solution to mitigate climate change. In this study, we estimated CO2 sequestration efficiency by measuring the population and community productivity of artificial reefs (ARs) implanted with seaweed (i.e., dominated by Ecklonia cava). The community-level CO2 uptake rate in the seaweed beds of ARs was measured using a large incubation chamber in July and October 2021 in Yangyang-gun in the East Sea of Korea. From these experiments, gross CO2 uptake rates were 0.24~0.56 g C m-2 d-1 (1.02~2.21 g C AR-1 d-1). We also measured the individual photosynthetic rate of E. cava (population level) and the gross CO2 uptake rate of each individual. The gross photosynthesis and respiration rates were 132.5 mg C ind.-1 d-1 and 1.05, respectively. Based on these results, we estimated the carbon sequestration process at the community level in the seaweed beds of ARs. Ninety-five percent of gross productivity was allocated for the respiration of E. cava, but seaweed-associated metabolism at different trophic levels (i.e., microbial and meiofauna/macrofauna respiration) was allocated an additional 74% of gross productivity, creating a net heterotrophic environment.

Determining the fate of *Laminaria hyperborea* detritus in the Irish Sea using species-specific DNA markers

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Knowledge of the fate of kelp biomass to shelf and deep seas is important for our understanding of carbon sequestration potential. Kelp forests have high annual turnover of biomass, from 460 g C $m^{-2} yr^{-1}$ to 3000 g C $m^{-2} yr^{-1}$ globally, with an estimated 80% exported to shelf and deep-sea environments. *Laminaria hyperborea* could make a significant contribution to exported material each year through the May Cast, where the entire prior year's blade growth is released into the water column. Current methods for identifying detrital material include carbon isotope analysis or eDNA, which have their limitations in differentiating to species level. As input from different macroalgal species can vary so widely, it is important to develop targeted means of identifying kelp sink locations, so that carbon flow dynamics can be better understood. This study tested the feasibility of using species-specific DNA markers to detect degraded seaweed material in Irish Sea sediment and water samples. This was used in combination with a hydrodynamic model to contextualise how seaweed material moves around the Irish Sea and what this may mean for carbon sequestration in offshore marine environments. Organic material reaching offshore sediment is expected to be degraded, which is why the success of this feasibility study is so exciting.

Abstracts

Leveraging the NIST Dietary Supplement Laboratory Quality Assurance Program for the Compositional Analysis of Seaweeds

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The National Institute of Standards and Technology (NIST) and World Wildlife Fund (WWF) are collaboratively working to advance the global seaweed farming industry. A major component of these efforts is the need for certified reference materials and methodologies for the compositional analysis of seaweed. In the spring of 2022, NIST's Dietary Supplement Laboratory Quality Assurance Program (DSQAP) was leveraged to identify discrepancies across the industry and identify methodologies that require standardization. While NIST QAP exercises are not proficiency tests (PT) and are not intended to pass strict evaluation of laboratory performance, they are conducted according to ISO/IEC 17043 and are designed to assist participants in evaluation and improvement of their measurement capabilities. Additionally, industry stakeholders can observe measurement challenges and NIST gains knowledge to guide the production and maintenance of reference materials.

Studies offered within the DSQAP Exercise 1 included the analysis of key elements, vitamins, per- and poly-fluoro alkyl substances (PFAS) contaminants, phenolic content, and proximates in different seaweed species (i.e. *Saccharina latissimi, Ascophyllum nodosum*). Seventy-five laboratories registered for at least one study and received samples from NIST for analysis. Results were returned to NIST and evaluated for accuracy, precision, and method bias.

This presentation will summarize the results of DSQAP Exercise 1 and provide technical recommendations for the seaweed measurement community. In the near future, NIST and WWF will organize a workshop for DSQAP participants and anyone else who is interested to provide more details on DSQAP findings, connect the seaweed farming measurement community, and discuss next steps.

Abstracts

VARECH project: Valorization of beach-cast seaweeds in Normandy (France)

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The aim of this project was to offer viable solutions to the socio-environmental problems of beach-cast seaweeds in Normandy. In Grandcamp-Maisy, the beach-cast was heterospecific with red, brown, and green macroalgae, mainly coming from a reef stretching for 5,60 km^2. During almost 3 years, beach-casts were studied: biomass, floristic biodiversity but above all, analytical composition with the goal to determine the baseline composition of this heterogeneous biomass. The objectives were two-fold: 1- find added-value for the heterogenous biomass, and 2- investigate the harvesting impact of the invasive *Sargassum muticum* on the reef before it is torn into beach-cast. Regarding the first axis, several added-value applications were explored generating very interesting results due to the diversity of biomolecules in these mixes of seaweeds. However, the most promising applications in term of economic viability are, on the one hand, the incorporation of these seaweeds in bioplastics - a proof of concept was the production of 500 "Ecocups" – and, on the other hand, the production of a liquid bio-stimulant. An extraction process has been developed to obtain compounds of interest, notably oligosaccharides and peptides, both at lab and pilot scale. The formulated extracts have proved bio-stimulant activity on agronomic tests : first on germination assays, then on lettuce cultivation improving drought resistance (+62% biomass). Moderate analytical variations of beach-cast allowed to maintain a baseline composition and the bio-stimulant activity in the extracts. A biorefinery model can be suggested by recycling the co-product of biostimulant extraction process into bioplastics.

Abstracts

Selection and sustainable valorization of Irish macroalgae by integrating natural variability (BlueBio MINERVA)

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Marine macroalgae are highly diversified organisms whose productivity and associated chemical composition vary greatly according to environmental fluctuations. Seaweed physiology is impacted by gradients in abiotic factors at different spatial (*i.e.* from few centimeters to several kilometers) and temporal (*e.g.* tidal, seasonal, inter-annual) scales, and responses are additionally subjected to climate change. This complex natural variability needs to be considered from a valorisation perspective since steady biomass production and composition are key in ensuring sustainable exploitation of natural populations, without modifying the key ecosystem services that macroalgae provide. A specific objective of the BlueBio Cofund project MINERVA ('*Marine Innovation using Novel Enzymes for waste Reduction and Valorisation of Algal Biomass*') is thus to assess and optimise natural seaweed biomass for subsequent integration into efficient biorefinery processes across diverse industrial sectors. To this end, seasonal screening of total phenolic content (TPC), pigment composition and antioxidant capacity of Irish macroalgal species was undertaken to identify local biomass with highest potential. Methodological comparisons were carried out to identify and apply most relevant protocols for the assessment of natural variability. In addition, for the commercial species *Ascophyllum nodosum* (Phaeophyceae, Ochrophyta), temperature responses were evaluated by Pulse-Amplitude Modulated (PAM) chlorophyll fluorescence, CO_2-absorption and O_2-evolution, and related to antioxidant capacities. Results highlight the effect of environmental change on algal physiology and associated chemical composition for specific high-value applications, and particularly the effect of climate change in the context of long-term sustainable exploitation of macroalgae.

Abstracts

Future protein supply from tropical seaweed: an exploration

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Protein needs have increased over time with the increase in the human population. Increased protein demand will place pressure on the production of existing sources mainly terrestrial vegetable and animal-based proteins. The terrestrial protein sources are now getting more constrained by the increasingly limited availability of land and supply of fresh water. It is necessary to find alternative complementary protein sources that are not only environmentally friendly but also do not require the availability of land and fresh water and can be produced sustainably. Seaweed is a sustainable biological resource that is a promising alternative because it is rich in protein. Indonesia is one of the largest seaweed producers in the world, although current seaweed cultivation is for carrageenan and agar production. However, with high seaweed biodiversity of as many as 911 species, the potential for the development of high protein seaweed is possible. Exploration was conducted to find future protein supply from tropical high protein seaweed *Porphyra* spp. in Indonesia. The explorations were conducted from June-November 2021 in the central and eastern parts of Indonesia. In 30 locations explored by considering the natural habitat and conditions of the growth of *Porphyra* spp., two natural growth locations habitat of *Porphyra* spp in Indonesia were located, namely in Ambon and Bali. The discovery of these locations shows the potential for the cultivation of future protein sources of *Porphyra* spp. in Indonesia considering that this species can live and grow in its natural habitat in the tropical waters of Indonesia.

Abstracts

Seaweed beach-casts: Are these valuable and safe resources?

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Seaweed beach-casts are unattached macroalgae which could disturb several activities on the coastline. We hypothesize that it could be used as a source of raw material for biocompounds purification. Other uses for this biomass include obtaining liquid extracts and dried biomass for crop fertilization and biofortification. In this work, nineteen samples from Playa de Las Canteras, Gran Canaria, were assessed, comprising November 2016 and May 2019. Several parameters were assessed including moisture content (4.81 - 10.86 g.100g^{-1} dw), protein (3.98 – 9.56 g.100g^{-1} dw), lipids (2.19 – 6.77 g.100g^{-1} dw), total phenolic content (0.01 – 0.99 mg GAE.100g^{-1} dw), Chlorophyll *a* (23 – 66 mg.100g^{-1} dw) and *b* (5 – 15 mg.100g^{-1} dw), total carotenoids (4 – 34 mg.100g^{-1} dw) and fucoxanthin (2 – 35 mg.100g^{-1} dw). Regarding the mineral content (36.30 – 75.88 g.100g^{-1} dw), calcium (5.12 –30.52 g.100g^{-1} dw), magnesium (1.07 – 2.45 g.100g^{-1} dw), potassium (0.73 – 4.68 g.100g^{-1} dw), phosphorus (0.07 – 0.12 g.100g^{-1} dw), iron (306 – 555 mg.100g^{-1} dw), iodine (17.66 – 59.81 mg.100g^{-1} dw), boron (12.4 – 35.6 mg.100g^{-1} dw) and manganese (8.5 – 31 mg.100g^{-1} dw) were analysed. Heavier elements included chromium (1.05 – 3.91 mg.100g^{-1} dw), zinc (1.0 – 4.9 mg.100g^{-1} dw), nickel (0.26 – 1.94 mg.100g^{-1} dw), copper (0.17 – 0.37 mg.100g^{-1} dw), cadmium (0.02 – 0.11 mg.100g^{-1} dw), lead (0.01 –0.21 mg.100g^{-1} dw) and mercury (0.32 – 1.16 µg.100g^{-1} dw). Targeting key fluctuation periods of heavier elements and biochemical compounds, could be useful to develop a safer and economical feasible industry. Associating biorefinery strategic plans for multi-compound extraction, could also increase the economic and environmental benefits.

Abstracts

The use of seaweed-derived phytosterols to defeat Alzheimer's Disease

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Accumulating evidence indicates a key role for a disturbed cerebral cholesterol transport in the development and progression of Alzheimer's Disease (AD). We showed that memory of AD mice improves upon activation of brain cholesterol turnover by synthetic activators of liver X receptors (LXRα/β). However, serious side effects including hepatic steatosis render these LXRα/β activators unsuitable for patients. We found that the seaweed *Sargassum fusiforme*, containing preferential LXRβ-agonist 24(S)-saringosterol, prevented memory decline and reduced Aβ deposition in an AD mouse model without inducing hepatic steatosis. However, *Sargassum fusiforme* also contains relatively high amounts of toxic elements such as inorganic arsenic (iAs), hampering the translation to humans. The use of a pure compound could serve as an alternative. We examined the effects of purified 24(S)-saringosterol on cognition and neuropathology in AD mice. Six-month-old male APPswePS1ΔE9 mice and wild-type C57BL/6J littermates received 24(S)-saringosterol (0.5 mg/25 g body weight/day) (APPswePS1ΔE9 n=20; C57BL/6J n=19) or vehicle (APPswePS1ΔE9 n=17; C57BL/6J n=19) via oral gavage for 10 weeks. Cognition was assessed using object recognition and object location tasks. Sterols were analyzed by gas chromatography/mass spectrometry, Aβ and inflammatory markers by immunohistochemistry, and gene expression by qPCR. Hepatic lipids were quantified after Oil-Red-O staining. Administration of 24(S)-saringosterol prevented cognitive decline in APPswePS1ΔE9 mice without affecting the Aβ plaque load. 24(S)-Saringosterol prevented the increase in inflammatory marker Iba1 in the hippocampus and cortex of APPswePS1ΔE9 mice. 24(S)-Saringosterol did not affect the expression of lipid metabolism-related LXR-response genes in the hippocampus nor the hepatic neutral lipid content. Thus, administration of 24(S)-saringosterol prevented cognitive decline in APPswePS1ΔE9 mice independent of effects on Aβ load and without adverse effects on liver fat content. The anti-inflammatory effects of 24(S)-saringosterol may contribute to the prevention of cognitive decline. Currently, we are investigating the potential of a *Sargassum fusiforme* extract free of heavy metals generated by supercritical fluid extraction and other seaweed species containing limited amounts of these toxic elements

Potential of *Himanthalia elongata* in the treatment of Alzheimer's disease

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Liver X receptor(LXR)α/β are promising therapeutical targets for treatment of AD as key regulators of both cholesterol homeostasis and inflammatory processes. We found that decline of memory and accumulation of amyloid (A)β in an Alzheimer's disease (AD) mouse model was prevented by dietary supplementation with the Asian brown seaweed *Sargassum fusiforme*, containing the LXR-agonist 24(S)-saringosterol. No adverse effects, such as hepatic steatosis, were observed. We examined if *Himanthalia (H.) elongata* harvested from the North Sea, containing similar concentrations of 24(S)-saringosterol as *S. fusiforme*, could prevent development of cognitive decline and neuropathology in AD mice. First, we demonstrated LXR-activating capacities of *H. elongata* lipophilic extracts using a Luciferase assay. Accordingly, expression of LXR-target genes was upregulated by *H. elongata* extracts in several cell lines. Subsequently, we assessed the effects of administration of *H. elongata* based on its 24(S)-saringosterol content (0.5 mg/25 g body weight/day) for 10 weeks to six-month-old male APPswePS1ΔE9 mice and wildtype C57BL/6J littermates on cognition assessed by object recognition and location tasks: *H. elongata* administration prevented cognitive decline in APPswePS1ΔE9 mice. Presently we are assessing the effects of treatment on neuropathology, including a.o. Aβ plaque load, inflammatory markers, and synaptic density and on cholesterol turnover. Potential adverse effects will be assessed by determining hepatic neutral lipid content and gene expression patterns. In conclusion, *H. elongata* administration prevented cognitive decline in APPswePS1ΔE9 mice and, although effects on neuropathology remain to be determined, appears to be promising for prevention or treatment of features of AD.

24(R, S)-Saringosterol - From artefact to a biological medical agent

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Enhancing the cholesterol turnover in the brain via activation of liver x receptors (LXR) can restore memory in a mouse model for Alzheimer's disease (AD). The edible Asian brown alga *Sargassum fusiforme* (Hijiki) contains high amounts of oxysterols such as 24(S)-saringosterol that are a potent liver x receptor (LXR) agonists. We aimed to find native European seaweed species with contents of 24(S)-saringosterol that are comparable to those found in *Sargassum fusiforme*. Additionally, we hypothesize that seasonal variations modify the amount of 24(S)-saringosterol in seaweeds. Sterols and oxysterols were extracted with chloroform/methanol from various seaweed species harvested in the Eastern Scheldt in different seasons between October 2016 and September 2017. Identification and quantification of the lipids was performed by gas chromatography (GC)-mass spectrometry and GC- flame ionization detection. We confirmed that brown algae *Undaria pinnatifida* harvested in February and *Sargassum muticum* harvested in October contained the highest amounts of 24(R,S)-Saringosterol (32.4 ± 15.25 µg/g and 32.95 ± 2.91 µg/g, mean ±S.D., respectively) and its precursor fucosterol (1.48 ± 0.11 mg/g), higher than *Sargassum fusiforme* (20.94 ± 3.00, mean ±S.D.), while *Ascophyllum nodosum* and *Fucus vesiculosus* and *Fucus serratus* contained amounts of 24(R,S)-Saringosterol (22.09 ± 3.45 µg/g, 18.04 ± 0.52 µg/g and 19.47 ± 9.01 µg/g, mean ±S.D., respectively) comparable to *Sargassum fusiforme*. In other algae only minor amounts of these sterols were observed. The green algae *Ulva lactuca* (0.29 mg/g fucosterols and 10.3 µg/g saringosterol) and Codium species (not detectable), and all investigated red algae did not contain any 24(R,S)-saringosterol or fucosterol. In the Eastern Scheldt algae harvested in September/October delivered the highest yield for 24(R,S)-saringosterol, with the exception of *Undaria pinnatifida* that showed the highest levels in February. We showed that exposure of lipid extracts of *Ulva lactuca* to sunlight at room temperature or in the presence of oxygen to UV-C light lead to the quantitative conversion of fucosterol into 24(R,S)-saringosterol. Exposing pure fucosterol to UV-light did not convert any fucosterol into 24(R,S)-saringosterol underscoring the requirement of seaweed constituents in the conversion of fucosterol into 24(R,S)-saringosterol. In conclusion, we showed that brown seaweeds harvested from the Eastern Scheldt contain amounts of 24(S)-saringosterol comparable to Sargassum fusiforme, varying per season and showing the highest amounts in spring. In accordance with these observations the amount of 24(S)-saringosterol in the brown seaweeds can be modulated by light.

Abstracts

Dietary Sargassum fusiforme improves memory and reduces amyloid plaque load in an Alzheimer's disease mouse model

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Activation of liver X receptors (LXRs) by synthetic agonists was found to improve cognition in Alzheimer's disease (AD) mice. However, these LXR agonists induce hypertriglyceridemia and hepatic steatosis, hampering their use in the clinic. We hypothesized that phytosterols as LXR agonists enhance cognition in AD without affecting plasma and hepatic triglycerides. Phytosterols previously reported to activate LXRs were tested in a luciferase-based LXR reporter assay. Using this assay, we found that phytosterols commonly present in a Western type diet in physiological concentrations do not activate LXRs. However, a lipid extract of the 24(S)-Saringosterol-containing seaweed Sargassum fusiforme did potently activate LXRβ. Dietary supplementation of crude Sargassum fusiforme or a Sargassum fusiforme-derived lipid extract to AD mice significantly improved short-term memory and reduced hippocampal Aβ plaque load by 81%. Notably, none of the side effects typically induced by full synthetic LXR agonists were observed. In contrast, administration of the synthetic LXRα activator, AZ876, did not improve cognition and resulted in the accumulation of lipid droplets in the liver. Administration of Sargassum fusiforme-derived 24(S)-Saringosterol to cultured neurons reduced the secretion of Aβ42. Moreover, conditioned medium from 24(S)-Saringosterol-treated astrocytes added to microglia increased phagocytosis of Aβ. Our data show that Sargassum fusiforme improves cognition and alleviates AD pathology. This may be explained at least partly by 24(S)-Saringosterol-mediated LXRβ activation.

Blanching of fresh sugar kelp should remove the fear and market barrier

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Fresh sugar kelp was harvested from five geographical locations Denmark, Sweden, Norway, Faroe Island, and Greenland in the summer (Early May – Mid July) 2020 and freeze-dried, vacuum dried, sun-dried, hot-air dried at 40 °C and 70 °C, blanched for 120 s and 20 s at 80 °C and fermented using various strains of lactobacillus. The tough structure of the cell wall allows seaweed to grow in the marine environment, but such complex polysaccharides present in the cell wall are hard to digest, and also this layer acts as a sponge for the trace metals.

Concentrations of potentially toxic elements (PTE) comply with regulations after processing in the US and Scandinavia, and therefore this study should remove the fear of contaminants as market barriers. The initial concentration of iodine I in kelp collected from Norway and Sweden (in excess of 6,000 mg/kg dry weight) is a matter of concern due to due to French recommendations. However, blanching is seen to be most effective for reducing the concentration of iAs and I. The final concentration of I in all the blanched samples irrespective of their geographical origin is less than 1,000 mg/kg of dry weight, whereas it seems ineffective against Hg and Cd ions.

Further investigations on the digestion models (INFOGEST) as well as/or a repeated study are needed, to make any concluding remarks related to the bioaccessibility of the compound of interest.

Abstracts

Investigating the effect of microwave-vacuum drying, freeze-drying and hot air drying of *Ulva* spp and *Fucus vesiculosus*

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Seaweeds contain 80-95% water, which makes them a highly perishable food product. Drying is used to stabilize foods by removing water, thus increasing their shelf-life. However, the drying method influences the end-quality: chemical, sensory- and physico-chemical properties. The two seaweed species *Ulva* spp and *Fucus vesiculosus* are growing as wild populations in the Danish inner waters and are of industrial interest for the use of food production. This study aimed to investigate different drying methods and evaluate their impact on the end-quality of the selected seaweeds.

The methods investigated were hot air drying (50 °C, 1 atm), freeze-drying (-40 to -10 °C, 20 Pa), and microwave-vacuum drying (-40 °C, 10 Pa).

Results showed that the drying methods changed the quality of the seaweeds differently. The *F. vesiculosus* dried by microwave-vacuum resulted in a lower water content than *Ulva* spp dried by the same method. In addition, water absorption showed that *Ulva* spp absorbed twice as much water as *F. vesiculosus,* explaining why *Ulva* spp was more resistant to dry (long drying time). Hot air drying and microwave-vacuum drying preserved the valuable pigment fucoxanthin in *F. vesiculosus*, whereas freeze-drying did not. Sensory profiling also showed that the drying methods did not change the sensory for *F. vesiculosus,* but the drying methods changed the sensory of *Ulva* spp (had different profiles between the drying methods).

Overall, we concluded that the choice of drying method affects the overall quality of the dried seaweeds and that one drying method might be more suitable for one type of seaweed than the other.

Abstracts

Brining as a stabilising method for Ulva fenestrate biomass

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Green seaweed, such as *Ulva* spp., has become of interest to the aquaculture industry because of its resilience to nutrient, salinity and temperature variations. However, the biomass rapidly perishes after being harvested due to its high moisture content and abundance in compounds stimulating microbial growth, e.g. cellulose. Thus efficient yet mild methods to preserve the quality of *Ulva* spp. are needed to facilitate its use as a food ingredient. In the BlueGreen project, tailor-made methods are developed for stabilizing *Ulva* spp. biomass in terms of its microstructure, texture, colour, volatile compound profile and nutritional properties. In this specific sub-project, brining of *Ulva fenestrata* was in focus, an area where very little research has been done.

Fresh *Ulva fenestrata* was subjected to analyses of nutrients (e.g., proteins, fatty acids), colour, texture, pH, salinity, and microbial load. For brining, the biomass was then placed in sealed containers at brine to seaweed ratios of 1:10. The brines were prepared with salt concentrations varying from 2-26 Brix°. The Brix° of the brines, as well as water activity, protein content, fatty acid composition, colour, microbiological load and tensile strength of the *U. fenestrata*, were then monitored over 2 months or until spoilage occurred. For the microbial load analyses, plate count agar and Marine agar were incubated at 25°C, and Long and Hammer agar were set at 15°C. The colonies were counted, isolated and Gram stained to identify, tentatively, the microorganism on the different brines over time.

Preliminary results reveal that *U. fenestrata* in salt brines ≥15 Brix° remained at a low coliform counts for >40 days, and the water activity of the seaweed was reduced from the native 0.94 to 0.85. However, salt brine, with 26 Brix°, was needed to retain the greenness of the *Ulva* blades. Additional results on e.g., microbiology, nutrient composition and volatile compounds will also be presented and discussed.

Safety, physicochemical attributes and consumer acceptance of *Saccharina latissima* preserved by salting

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The volume of aquacultured macroalgae produced in the northeastern USA has increased by nearly 10x since 2018 (Maine DMR). The remoteness of most existing farms and lack of centralized processing infrastructure in the region underlie the need for low-input processes for shelf life extension. We assessed the effects of salting treatments (dry salting [30% NaCl wt/wt] and brining [40% NaCl]) on quality, safety and palatability of *Saccharina latissima.* Salted algae was stored at 4°C or 22°C for up to 90 days. Physicochemical (water activity, moisture, color, mineral content), and microbial properties (aerobic mesophilic, psychrotrophic, marine bacteria counts) were assessed. Both treatments reduced water activity from 0.98 to ~0.74. Microbial quality remained high (<3.0 logCFU/g) in all treatments through 60 days of storage, regardless of temperature, but psychrotrophic bacteria increased significantly between days 60 and 90 in samples stored at 22°C. Potassium, magnesium and calcium concentrations were significantly higher in dry salted kelp than untreated or brined samples. Subsequently, foodborne pathogens of interest (shigatoxigenic *E. coli (*STEC), *Salmonella, Vibrio* spp., *Listeria monocytogenes*) were inoculated onto kelp before salting and survival during processing and storage was assessed. Salting significantly reduced populations of all four pathogens, with initial reductions ranging from 1.0 (*Salmonella*) – 2.9 (*Vibrio* spp.) logCFU/g. *L. monocytogenes* and *Salmonella* were significantly more resistant to treatment than STEC or *Vibrio* spp. Collectively, data illustrate the capability of salting treatments to produce consumer products with enhanced shelf life and safety without requiring significant capital or input cost on the part of the grower/processor.

Abstracts

Influence of storage time and dehydration methods on microbiological and physiochemical quality of brown seaweeds

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Brown seaweed (*Alaria esculenta* and *Saccharina latissima*) can potentially be the future North Atlantic Ocean crop. One of the main bottlenecks in upscaling seaweed production is the need to stabilise the annual harvest before it spoils. We investigated the microbial quality changes during chilled storage of brown seaweeds and subsequent stabilization by either convection or ambient atmospheric drying. The quality of the dried seaweeds was determined by the swelling, water-, and lipid-binding capacity. Microbial loads (3M Aerobic Count Plate) were 4.0-4.5 log(CFU/g) at the time of harvest for the two species. The microbial numbers increased to 5.9-6.1 log(CFU/g) after seven days of storage at 2-3 °C. For fresh seaweed, the drying process had limited impact on the bacterial load, with reductions of 0.1 to 2.9 log(CFU/g) during the process. In contrast, the same drying process resulted in reductions of 4.2 to 5.8 log(CFU/g) for seaweed, which had been stored for 7-days prior to the drying. Dried *S. latissima* showed higher swelling and water-binding capacities compared to *A. esculenta* regardless of the drying method. Drying at the ambient atmosphere yielded a higher lipid-binding capacity for both species than convection drying. Based on the bacterial concentrations, the seaweed should be stabilised within the first five days of chilled storage post-harvest. Convection drying inactivates more bacteria and has a shorter process time. However, if the seaweed is intended for use in a lipid-rich product, such as pesto, the use of ambient atmospheric drying might be beneficial.

Abstracts

Towards more successful seaweed fermentations: screening approaches and potential of lactic acid bacteria fermentation in Nordic brown seaweed *Saccharina latissima*

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Seaweeds contain many beneficial nutrients and have prebiotic properties. They show great potential as source of carbohydrates and proteins and might be used to create nutritious and sustainable food products, where no land is needed. With the increasing attention of seaweeds for food applications, there is a high demand in developing new processing and preservation methods. Lactic acid bacteria (LAB) fermentation has been a well-known post-harvest technique which increased the shelf life of fresh produce. Apart from the preservation capabilities, LAB can also modify the organoleptic characteristics of the fermented foods and improve the likability of the products. This research aims to describe a fast and reliable methodology for rapid screening of LAB for their ability to grow in brown seaweed and preserve the algal biomass post-harvest. A preliminary study of available genomic data was conducted in order to determine the presence of essential genes mainly for mannitol utilization. For the present work, 261 bacterial isolates were screened in seaweed media with buffering system for their acidification ability using a colorimetric method in 96-well plates. The selection criteria will be based on acidification rate (ΔpH), the generation of desirable organic acids by HPLC and tolerance in different salt concentrations in seaweed media. The overarching goal is to explore the potential of LAB, isolated from various land sources, as starter cultures in Nordic brown seaweed *Saccharina latissima* with special focus on the modification of flavor profile.

Abstracts

Towards an Integrated Platform for Eucheumatoid Cultivar Development

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Eucheumatoid farming has been carried out in massive scale in many tropical oceans for more than 50 years primarily by vegetative propagation. Farmers are facing increasing challenges such as unpredictable growth and disease believed to be caused, in part, by the lack of genetic diversity. Lessons from land crops wherein similar issues have been overcome successfully can effectively guide efforts for successful macroalgal aquaculture.

Curating and understanding existing germplasm under cultivation began with the development of a strain bank housing samples of cultivated eucheumatoids from different locations in Indonesia. ISSR-PCR based DNA fingerprinting was used to investigate genotypic variation among these and other isolates from the Philippines. Besides cross-breeding with wild varieties and enhanced techniques for spore germination and maturation, we are also attempting to generate new varieties by mutagen-treated tissue culture and micro-propagation techniques. To screen these newly generated variants for growth and biomass yield, scaled-down processes (2-100L tanks) of eucheumatoid aquaculture with predictable and consistent growth characteristics repeatable across different laboratories has been developed. The effects of variety of growth-influencing elements using these systems were examined, including water motion, nutrient levels, light, and temperature. Miniature raceway systems were designed to mimick ocean conditions for enhanced sporeling and micropropagule growth. Additionally, we are working on a rapid and reliable method for scaling-up small amounts of biomass to plantation-ready quantities. Finally, our precision ocean farms have the capability of handling multiple varieties and species for monitoring performance and screening for the best varieties, which is key for sustainable eucheumatoid aquaculture.

Abstracts

Innovative measures for growing eucheumatoids and mitigating ice-ice and epiphyte incidences using *Ascophyllum nodosum* extract

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The use of a phyco-biostimulant from the brown alga *Ascophyllum nodosum* has been widely used in agricultural crops for decades. However, it was recently discovered that the same extract can be successfully applied in the micropropagation and field cultivation stages of eucheumatoids.

The present study tested the efficacy an alkali extract from *A. nodosum* on *Kappaphycus alvarezii* (aka AMPEP) with the aim of enhancing growth rate and mitigating ice-ice disease (IID) and the incidence of epiphytes. Three innovative measures were used to grow the seaweed using super twine and PER#4 in tying the seedlings and also growing the same seaweeds in tubular nets with prior dipping with AMPEP for 1 hr before outplanting in the sea. A total of three growth cycles of 45 days each from November to June (representing the dry months) were followed. Ice-ice disease and epiphyte incidences (%) were measured and correlated with the prevailing water quality.

Mean DGR of thalli treated with AMPEP, using the three cultivation methods used were significantly ($p<0.05$) different during the three consecutive growth cycles. However, it was observed that during the third growing cycle (May-June), negative growth was recorded in double loops and super twine despite the AMPEP treatment. Growth rates, IID and epiphyte incidences were significantly correlated with temperature and salinity at $p<0.01$. The same parameters did not significantly correlate with IID and epiphytes, except for DGR at $p<0.05$.

This study clearly demonstrated the effects of increased temperature and salinity brought by environmental change on *Kappaphycus* growth rates, IID and epiphyte incidence. The cultivated biomass was also processed for semi-refined carrageenan and data on yield, viscosity and gel strength will be presented.

Abstracts

Tetrasporogenesis and sexual reproduction in *Kappaphycus alvarezii* (Gigartinales, Florideophyceae) for new seedstock development and selective breeding

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Vegetative propagation in mariculture ensures the preservation of desirable traits and safeguards the quality of the farmed cultivars. This practice, however, negates genetic exchange over time which leads to low genetic variation and decline in plant vigor. High genetic variation enables growth in wide range of environmental conditions especially in a changing climate. To provide alternative seedstocks for the commercially farmed cultivars/haplotypes, selection from the hatchery-reared progenies of wild reproductive individuals can provide new seedstocks and different male and females individuals for selective breeding. Currently, there is paucity of information concerning the reproductive characteristics and germling growth under nursery or hatchery condition. This study focuses on the morphological comparison between the parental plants, its corresponding offsprings, and variation within cohort. Development of reproductive structures and its fate over time under hatchery conditions is also documented. Furthermore, evidence of chimeric individuals resulting from early-stage coalescence is also presented.

Abstracts

Effects of nutrient supply on growth and biochemistry of *Kappaphycus alvarezii*

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The supply of macronutrients nitrogen (N) and phosphorus (P) regulates seaweed photosynthesis, growth, and subsequent flow of photosynthate into various biochemical compounds. This study investigated the growth performance and biochemistry of *Kappaphycus alvarezii* (strain TR-C5) under control (*ctrl*/ambient seawater), and one-time (*1×*, i.e., only at the start of the experiment) and intermittent (*5×*, i.e., every 10 days) pulse feeding with inorganic nutrient using a commercially available, ammonium-phosphate (16-20-0 NPK composition) fertilizer under hatchery condition for 50 days. Fertilization every 10 days showed significantly higher growth rate, and greater nitrogenous (e.g., chlorophyll *a* and protein) and carbon-based (carbohydrate) compounds compared to the *ctrl* and *1×* treatments suggesting that the fertilization strategy employed had a direct effect on N and carbon (C) metabolism. Conversely, inorganic nutrient fertilization negatively affected the carrageenan yield and quality (viscosity and gel strength) where the *ctrl* produced the highest values compared to *1×* and *5×* treatments. In this regard, the use of inorganic nutrient fertilizer employed by commercial seaweed farmers to enhance production and minimize incidence of e.g., ice-ice disease must be properly managed without compromising carrageenan yield and quality. When additional nutrition is applied, and maximum growth and biomass are already achieved, the farmed *Kappaphycus* should be allowed to metabolize excess nitrogen for at least 14 days from the last pulse feeding schedule. This will allow the seaweed to allocate C for the production and storage of cell wall polysaccharide.

Development and Application of Molecular Genetic Resources for the Genetic Advancement of *Kappaphycus alvarezii*

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The sustainability of eucheumatoid production must balance the productivity of monoculture with the need for genetic variation, to adapt to increasing biotic and abiotic pressures. We are characterizing the genetic composition and variation in wild and farmed *Kappaphycus alvarezii* (Kalv) in the Philippines and Brasil.

To facilitate these studies we have developed the *Kappaphycus alvarezii* Genome Explorer (KaGE) by annotating and integrating the Kalv reference genome (BRAKER2) and curated public and private gene expression data (FINDER), and predicting a proteome based on homology, phylogeny and hidden Markov models (eggNOG, MCL, BLAST2GO, InterProScan, Kofam-KOALA, dbCAN2). Further, we built a JBrowse genome explorer that tracks the location and structure of coding and non-coding genes, repetitive elements, telomeres, polymorphisms, gene expression data, and DNA sequences targetable by CRISPR. KaGE is integrated with a functional annotation explorer that enables navigation of gene and transcript models, gene ontology, protein clusters, and metabolic networks & pathways (KEGG, BiGG, MetaCyc, REACTOME). Finally, we implemented a Galaxy pipeline to pre-process, map and quantify user data, with an RShiny Web application for conducting and visualizing over-representation and gene set enrichment analysis (ORA and GSEA).

Comparing the gene and repetitive-element complement in Kalv to other Rhodophytes, reveals genome expansions and apparent endosymbiotic gene transfer. Furthermore, SNP and RNAseq data effectively differentiated wildtype (brown vs green) and commercial cultivars, revealing metabolic pathways responsible for strain compositional differences. Additional DNA sequence, genotypes and gene expression data will facilitate the development of molecular genetic systems for managing and improving Kalv cultivars.

Abstracts

Regeneration and development of enzymatically-isolated protoplasts of *Kappaphycus* spp. (Solieriaceae, Rhodophyta)

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The decline in production and quality of *Kappaphycus* seaweeds reported in the Philippines since 2007 has been attributed to inadequate supply of good quality seedstocks. Traditionally, seedstocks for these species are vegetative parts from previous crops, resulting in deterioration of genetic quality and poor farming performance. Among the strategies pursued to solve the problem is production of improved strains from protoplasts, or living cells devoid of cell walls. However, the use of protoplasts in seedstock production and strain improvement for economically important seaweed *Kappaphycus* spp, is still not possible due to their low regeneration rate. This study was conducted to optimize conditions for regeneration and growth of protoplasts isolated from *Kappaphycus* spp. through enzymatic methods. Viable protoplasts from different strains of *Kappaphycus alvarezii* and *Kappaphycus striatus*, different tissue types (medullary, cortical) and ages (apical, basal) were isolated using a two-step enzymatic method. The protoplasts were embedded in carrageenan gel droplets and flooded with f/2 medium for 2-3 weeks, and were cultured in lighted shelves at different irradiance levels, at 22+ 2^0C and 12:12 L:D photoperiod. Protoplasts of subcortical cells obtained from the apical portion of seven farmed and wild strains of *K. alvarezii* collected from Surigao del Norte and Northern Samar regenerated into 5mm-12mm germlings (< 1cm plants) after 26-32 days of culture in gel droplets. Regeneration rate was 10-36% and two regeneration patterns were observed, resulting in development of either a dichotomously branched thallus, or a uniseriate, branching filaments in 6 months.

Abstracts

Impacts of aquaculture nutrient sources: ammonium uptake of commercially important eucheumatoids depends on phosphate levels

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In an IMTA system, seaweeds serve as extractive species that utilize excess nutrients thereby reducing the risk of eutrophication and promoting sustainable aquaculture. However, the use of excessive fish feeds and resultant fecal waste can contribute to variations in nutrient levels (e.g., primarily NH4+ and PO_4^{-3}) in the surrounding area and this may impact the physiology of the integrated seaweeds particularly on how these species take up inorganic nutrients. In this study, the effect of different PO_4^{-3} levels on NH_4^+ uptake of the three commercially important eucheumatoids *Kappahycus alvarezii*, *Kappaphycus striatus* and *Eucheuma denticulatum* was examined under laboratory conditions. Samples (n=3) were incubated in seawater media containing 30 µM NH_4^+, representing eutrophic conditions, and 0, 0.5, 1.0, 1.5, 3.0 or 5.0 µM PO_4^{-3} for 1 h under a saturating light level of 116 + 7.13 µmol photons m^{-2} s^{-1} inside a temperature-controlled room. Species-specific responses to PO_4^{-3} levels were observed. For *K. alvarezii,* maximum NH_4^+ uptake (17.8 ± 1.6 µmol g^{-1} h^{-1}) was observed at 0.5 µM PO_4^{-3} and the uptake declined at higher PO_4^{-3} levels. For *K. striatus*, the NH_4^+ uptake increases with increasing PO_4^{-3} levels, with maximum N-uptake of 6.35 ± 0.9 µmol g^{-1} h^{-1} at 5.0 µM PO_4^{-3}. For *E. denticulatum,* maximum NH_4^+ uptake (14.6 ± 1.4 µmol g^{-1} h^{-1}) was observed at 1.0 µM PO_4^{-3}. Our results have implications on the selection of seaweeds to be incorporated in an IMTA system particularly in mariculture areas where PO_4^{-3} levels significantly vary in space and time

Abstracts

Suitability of world seas and oceans for seaweed cultivation

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70% Of Earth's surface is covered with oceans. Their contribution to world food production is limited. Seaweeds currently contribute less than marginally to world food production. Much uncertainty and speculation exists on whether food production by seaweeds can be boosted to future significant levels. Here we present a quantitative exploration of production potential for seaweed cultivation. The model runs at a global scale, monthly timestep, with 1o (100x100km) spatial resolution. Biophysical site suitability is modelled taking into account environmental variables: ocean temperature, salinity, irradiation, nitrate concentration, phosphate concentration and wave height. Monthly site suitability is modelled on a scale from 0 to 1 (unsuitable to perfectly suitable). Presuming a minimum site suitability of 0.5 during a period of at least 6 months of the year we present maps of global site suitability.

Seaweeds use the same nutrient resources as phytoplankton, the base of the marine food web. A potential ecological concern with future large scale seaweed cultivation is that if competition is too strong, reductions in phytoplankton growth could lead to collapse of the marine ecosystem. To accommodate these concerns, potential production calculations were constrained, allowing only the sites with high nutrient concentrations to be cultivated and allowing only 1% of each gridcell (pixel) area to be cultivated.

Economic concerns limit potential sites to sites not too far offshore, but also not too close to the shore. Sites too far of shore are unprofitable because production costs (for harvesting and planting operations) increase with distance from shore. Too close to shore one finds the coastal zone is often also used intensively by other sectors (tourism, transport, fisheries). Biophysical potential was mapped for the whole world, and subsequently calculations of production potential were limited to the Exclusive Economic Zone (EEZ), a zone of 200 nautical miles (360km) out of shore. Sites close to shore are automatically excluded because the dataset provides poor coverage of these sites.

We explicitly consider the pathway from the current state to a possible future state of the seaweed sector. Agriculture on land is more than 10000 years old. Seaweed cultivation is currently still in it's infancy. Expecting production increases at rates higher than witnessed on land during the green revolution also seems unrealistic. A more realistic approach is extrapolating from historical seaweed production trends. We present scenarios of what could maximally be produced in the year 2050

Abstracts

Expert perceptions of seaweed farming for sustainable development

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Large-scale seaweed aquaculture in the ocean is being pursued globally as a solution to many contemporary challenges, including climate change, food security, and ecosystem degradation. However, the required development and transformation of marine systems for farming may have unknown implications for sustainability objectives, such as those outlined in the United Nations Sustainable Development Goals (SDGs). The aim of this paper is to outline the opportunities for, and threats from, seaweed farming in the context of sustainability. We synthesise the perspectives of expert stakeholders from multiple sectors through a series of Australian workshops to catalogue the pathways through which seaweed farming may affect sustainability, giving specific focus to the SDGs. In doing so, this study illustrates that seaweed farming has the potential to influence, to some degree, the majority of SDGs, with both positive and negative influences. Indeed, seaweed farming is most likely to benefit progress towards achieving SDGs 2 (Zero Hunger), 8 (Decent Work and Economic Growth), 9 (Industry, Innovation, and Infrastructure), 12 (Sustainable Production and Consumption), and 15 (Life on Land). But expectations of seaweed farming may also fall short for supporting some goals if appropriate measures are not implemented to mitigate potential impacts, most notably SDG 14 (Life Below Water). We underscore that seaweed farming has the potential to contribute to sustainable development, and that this potential can only be realised with appropriate regulation and mitigation to avoid unwanted negative outcomes. Better identification and management of trade-offs between these potential positive and negative outcomes across sustainability domains, will be critical for realising the full potential of seaweed aquaculture for sustainable development.

Abstracts

Nature´s Contributions to People derived from seaweed aquaculture

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The development of aquaculture has been supported by the demonstration that this activity can be sustainable from the environmental, economic and social perspective. Several Nature's Contributions to People (NCP), a novel framework for Ecosystem Services, were identified and quantified for selected seaweed farms in the EU projects AquaVitae and GENIALG, to inform a sustainability assessment.

The work was divided into four sub-tasks: i) identification of the NCPs provided by seaweed aquaculture ii) selection of specific Case Studies iii) selection of indicators for NCPs quantification; iv) quantification and analysis of selected NCPs.

NCPs identified and quantified for seaweed aquacultures assessed were "Regulation of coastal water quality" quantified using the indicators "Nutrient cycling" and "Eutrophication index"; "Regulation of climate" estimated with "Carbon footprint" indicator, "Regulation of ocean acidification" used "Ocean acidification index" and "Food and feed provision" was estimated using food and feed production. The performance of the selected seaweed aquaculture systems was subsequently analysed and quantified. Offshore sugar kelp production removed 1.05–2.57 kg N and 0.15–0.47 kg P per t fresh weight (FW) biomass harvested, which correspond to a maximum eutrophication mitigation potential of -2.5 kg PO_{4-}eq per t FW, presented an ocean acidification index of -93.1 to -96.5 kg CO_2/t FW, a neutral biological carbon footprint and a negligible total carbon footprint. The N and P removal by *Ulva rigida* produced at a land-based IMTA facility was estimated at 5.31 kg/Mt and 0.26 kg/Mt, and an ocean acidification index of -159.6 kg CO_2/t FW.

Based on the NCPs evaluated in this study, seaweed production showed great promise for future expansion, but a full evaluation including additional sustainability indicators (i.e., also social and economic) should be performed to ensure that an expansion does not lead to unpredicted negative effects.

Achieving social license to operate for seaweed farms across geographic contexts

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Social license to operate is defined as an ongoing negotiation between a community and an entity that has social and environmental implications associated with its activities and requires the support and trust of its community to be successful (Rooney 2014, Billing 2018). Achievement of social license may be one of the most significant barriers the seaweed industry faces as it continues to expand, particularly along coastlines where farming is a relatively new activity and numerous users share limited ocean space. Any new seaweed farm or company must consider at the outset how they will build, and maintain, social license in their unique local context. This presentation will lay out challenges regarding community interactions faced by seaweed farming operations and describe case studies of strategies different organizations have employed to address social license in their local waters. Many of these experiences offer transferable learnings and ideas that bridge kelp farming regions, including what the industry can learn from recent message testing data that indicate ways to improve public perceptions of seaweed aquaculture.

Abstracts

Indonesian red seaweed as a potential source of mycrosporine like amino acid and phycocolloid for cosmeceuticals

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Seaweeds are rich-sources of structurally novel and biologically active metabolites, with great potential for cosmeceuticals. Seaweeds metabolites have function in cosmetics as additive, bioactive cosmetics and stabilization. Bioactive seaweeds can be applied for skin whitening, anti wrinkle, ptotoprotectant and anti photoaging. Metabolite diversity of red seaweed is richer than green or brown seaweed. Herein, we are going to deliver our research on exploring the potential of Indonesian red seaweeds as source of bioactive and additive agents for cosmetics. We examined 50 species of red seaweeds collected from Yogyakarta, Bali and East Nusa Tenggara for production of primary metabolite hydrocolloid and secondary metabolite mycrosporine-like amino acid (MAA). Seaweeds were extracted using methanol to obtain MAA and hot water-ethanolic to yield polisaccharide. Analysis were completed by employing UV-VIS spectroscopy and LC-MS for MAA. Type of hydrocolloid was analyzed using FTIR spectroscopy. Results indicated that Indonesian red seaweeds are promising sources of diveristy of MAA for photoprotectant, antiphotoaging and antioxidant. The diversity of phycocolloid showed types of carrageenan, agar and galactan sulfate for thickening and mousterizing for cosmetic application.

Abstracts

Enzymatic extraction of high purity fucoidans from brown seaweeds

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Fucoidans are heterogenous fucose rich polysaccharides that are found in the cell wall of brown seaweeds. Fucoidans have several interesting bioactivities, however, lack of knowledge about the structural elements that are responsible for these activities and the exact chemical compositions are limiting potential applications of fucoidans. Traditionally, fucoidans have been isolated from seaweeds using hot liquid extraction techniques, but depolymerization of the polysaccharide, high amounts of contamination and limited process control are major disadvantages of this extraction technique. In this study we report a new enzymatic extraction technique to produce pure and intact fucoidans from the two brown seaweeds *Saccharina latissima* and *Alaria esculenta*. This new extraction protocol uses fungal cellulases together with endo- and exo-acting thermophilic alginate lyases, to degrade the seaweed cell wall components and release the intact fucoidans. The fucoidans obtained by this extraction technique is compared to traditionally extracted fucoidans, in terms of chemical compositions and molecular weights, and are shown to contain significantly higher amounts of fucose, galactose, and sulfate, the main components of fucoidans, while cellulose, laminarin, and alginate contamination is low. Additionally, the enzymatic extracted fucoidans have higher molecular weights, as no degradation of the fucoidan was observed during the enzymatic extraction. The pure and more intact fucoidans extracted by this new method can be used to provide further insights into native fucoidan structures and their biological activities.

Abstracts

Blanching before pH-shift processing of *Saccharina latissima* retains protein extraction yields while minimizing iodine content

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The seaweed *Saccharina latissima* is often blanched to lower iodine levels, however, it is not known how blanching affects protein extraction. Therefore, we assessed the effect of blanching or soaking (80/45/12°C, 2 min) on protein yield after pH-shift processing of *S.latissima*. We also examined the influence of all water treatments and pH-shift processing on the protein/peptide size distribution and chemical composition, including elemental analysis, of biomasses and protein extracts thereof.

Average protein yields and extract amino acid levels ranked treatments as follows; blanching-45°C ~ control > soaking ~ blanching-80°C. Although blanching-45°C decreased protein solubilization yield at pH 12, it increased isoelectric protein precipitation yield at pH 2 ($p<0.05$). Analysis of the protein/peptide size distribution revealed a higher ratio of large peptides/proteins in the blanched biomass, which could explain the lower protein solubilization yield after blanching. Also, through a dialysis model, we confirmed a link between lower ionic strength after blanching and increased protein precipitation yield. Regarding elemental composition, blanching-45°C yielded a protein extract with 49% less iodine compared with the control extract from non-treated *S. latissima*. Non-essential elements such as cadmium, lead, and nickel were concentrated after blanching treatments. Nevertheless, iodine is still the element limiting consumption at higher amounts of all biomasses and respective protein extracts. The monosaccharide profile revealed that the up-concentration of those non-essential elements was probably due to an increased proportion of alginate after blanching.

We recommend blanching at 45°C since it is effective at removing iodine and does not compromise total protein extraction yield.

Optimisation of cellulase-assisted extraction of laminarin from the brown seaweed *Ecklonia maxima*

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Enzyme-assisted-extraction (EAE) could be a useful technology for the extraction of laminarin from brown seaweeds and has the advantage of mild processing conditions what retain bioactivity of the molecule, compared to conventional chemical extraction. Laminarin is a potential high-value β-glucan that exhibits multiple bioactivities useful in the food and nutraceutical industries. The work aimed to optimise extraction conditions for enzyme-assisted extraction of laminarin from the South African kelp, *Ecklonia maxima*, using response surface methodology. Celluclast®, a commercial cellulase, was used to hydrolyse *Ecklonia maxima* over a period of 6 hours, within the range of 0 to 4.0% (v/dw) enzyme–substrate ratio (ES), pH 3.0 to 6.0, and temperatures of 40 to 60 °C. Samples were analysed for solubilised yield (SY), and concentration of reducing sugars (RS) and laminarin (L). Extraction of laminarin was significantly influenced by linear and quadratic effects of pH and temperature, but not by ES over the experimental range. However, RS and SY showed a significant linear effect of the ES term. Compared to conventional dilute-acid thermal hydrolysis (DATH: pH 1.0 and 70 °C), enzymatic extraction was superior in releasing RS and increasing SY at 4.5 h of hydrolysis. However, conventional DATH was more selective toward extraction of laminarin and resulted in higher extraction yields. Future work should determine the chemical structure of the extracted laminarin and determine whether there are differences in bioactivity for laminarin extracted with EAE vs DATH-extracted laminarin.

Blue cellulose: The challenge of producing fibre grade cellulose from seaweed

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Textiles are responsible for about 10% of the total CO_2 emissions, and about 25% of all garments are incinerated or landfilled without ever being worn. Thus more sustainable fashion solutions are needed. Over 20% of the textile sector currently relies on cotton, a crop mostly grown outside the EU and with large environmental impacts (pesticides, intensive water and land use). To reduce this dependency and the environmental impact of traditional textile processes, a novel model for the textile industry is developed in the HEREWEAR project based on the local production of cellulose fibres derived from bio-based wastes, specifically agricultural and seaweed residues. This presentation focuses on the use of seaweed residues for producing cellulose based fabrics. Brown, red and green seaweeds all contain, to varying amounts, cellulose. The current hydrocolloid processes (alginate, agar agar and carrageenan), in principle, produce residues that contain cellulose. Furthermore, green seaweed contains the highly valuable polysaccharide ulvan, and cellulose can thus be obtained as side stream. Cellulose rich fractions can be used in the production of cellulosic textile filaments via the HighPerCell® technology developed by DITF, an environmentally benign alternative to the lyocell process. As part of HEREWEAR, approaches to maximise the recovery of both ulvan and cellulose residues have been explored. Furthermore, different routes to obtain seaweed based cellulose have been implemented at lab scale. Further upscaling of these processes have been attempted and key technology challenges are identified for the development of this process concept. Suitability of the refined seaweed cellulose fractions for fibre spinning through HighPerCell® technology is explored in this work. We also present an outlook for the use of alginate and ulvan in textiles.

Abstracts

Ulvan from filamentous and blade species of *Ulva* (chlorophyta) differ in structural and chemical composition

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Ulvan are sulfated polysaccharides from the green seaweed, *Ulva*. A host of bioactivities (e.g., anti-inflammatory, anti-viral, anti-hyperlipidemic) and a complex structure suggest potential applications for ulvan ranging from biomaterials to drug delivery molecules. However, much of the data underpinning these promising applications comes from polysaccharides extracted from *Ulva* with a blade morphology (e.g., the genus holotype, *U. lactuca*). In contrast, there is limited data on ulvans from filamentous morphologies of *Ulva*.

We used standardised procedures to characterise and compare ulvan from blade and filamentous species of *Ulva* collected from the Bay of Plenty, Aotearoa New Zealand. Distinct differences in the chemical composition, structure, and gelling properties of ulvans from blade (*U. australis, U. rigida, U*. sp. B, and *Ulva* sp.) and filamentous (*U. flexuosa, U. compressa, U. prolifera*, and *U. ralfsii*) species of *Ulva* were quantified. Ulvan isolated from blade species had higher yields (14.0-19.3%) and iduronic acid content (IdoA = 7-18 mol%), and lower molecular weight (Mw = 190-254 kDa) and storage moduli (G′ = 0.1-6.6 Pa) than filamentous species (yield = 7.2-14.6%; IdoA = 4-7 mol%; Mw = 260-406 kDa; G′ = 22.7-74.2 Pa).

The linkage composition and sulfation of four of these ulvans were then compared. The predominant residues present from all four ulvans where 1,4-rhamnose 3-sulfate and 1,4-glucuronic acid; 69-87 mol% combined. However, ulvans from filamentous species also contained high proportions of branching/sulfated residues not detected in ulvans from blade species, supporting the morphology-based division in these polysaccharides.

Abstracts

To gel or not to gel: Enzymatic desulfation of carrageenans for the modification of their rheological properties

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Carrageenans are a group of sulfated biopolymers that represent the commercially most relevant products obtained from red algae that are highly appreciated for their gelling behaviour or as thickeners and stabilizers in the food and cosmetic industry. The degree and position of sulfation has a decisive influence on their rheological properties and thus defines their commercial use. By the targeted cleavage of sulfate groups, e. g. by the use of sulfatases, carrageenan variants with new physico-chemical properties can be generated. To tackle this issue, we screened several putative carrageenolytic polysaccharide utilization loci of heterotrophic bacteria for sulfatases active on different types of carrageenans. Two carrageenan-active sulfatases were found in this approach, which were produced in an active form. They catalyze the specific desulfation of both ι- and κ-carrageenan as well as the hybrid carrageenan furcellaran. Spectroscopic analysis and desulfation experiments revealed the production of hybrid ι-α- & κ-β-carrageenan as well as highly pure α- & β-carrageenan, respectively. The enzymes were used for the biotransformation of ι- & κ-carrageenan in a preparative scale and the rheological analysis of the products uncovered the structure-function relationship of the sulfation architecture on their viscoelastic properties. These discoveries lay the groundwork for enzymatically modified carrageenans and their utilization in new application fields.

Structural and biochemical characterization of degraded iota carrageenan using enzyme produced by *Cellulophaga baltica*

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Degradation of polysaccharides plays an important role to improve the biochemical properties like antioxidant, tyrosinase inhibition, cell proliferation etc. In this study, iota carrageenan was hydrolyzed by polysaccharide degrading enzyme extracted from *Cellulophaga baltica*. iota carrageenan samples with varying degradation levels were obtained after 5 min, 30 min, 1 h, 3 h and 20 h enzyme treatment respectively. Among all degraded sample, S-8 showed 1.4, 2, 1.9, 2.5 and 1.8 times higher antioxidant activities for FRAP, SOD, ABST, DPPH and OH assays, compared to the control which is non-degraded iota. 50% inhibition of tyrosinase enzyme which is responsible for hyperpigmentation and melanogenesis was observed in case of S-8 whereas control showed 34.3% inhibition. Anticoagulant activity dropped to 5.5 µg/mL from 7.8 µg/mL after 20 h degradation. To determine cell cytotoxicity of degraded iota carrageenan, MTT assay was performed. For HaCaT cell line, highest cell proliferation was observed after 72 h whereas, for Raw 264.7 cells, highest cell proliferation was observed after 24 h. S-8 showed highest proliferation rate for the both cell lines. Scratch wound healing of S-8 exhibited a significant enhancement within 24 h compared with the control and at 48 h the wound was completely closed. NO production significantly decreased in S-8 treated RAW267.4 cells. Enzymatic degradation of iota carrageenan significantly enhanced the antioxidant activity, tyrosinase inhibition, cell proliferation and migration as well as decreased NO production compared with control. Degraded iota can be used as potential therapeutic agent in cosmeceutical and pharmaceutical industries.

Abstracts

Understanding drivers of kelp distribution and loss to inform kelp forest restoration in New Zealand

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Understanding the relative importance of different anthropogenic stressors in driving habitat loss is key to developing management strategies aimed at conserving and restoring marine ecosystems. Long-term declines in kelp forests on rocky reefs in Queen Charlotte Sound, New Zealand, have been suggested to be due several anthropogenic stressors including warming coastal waters, turbidity associated with land-use, and fisheries-driven trophic cascades. Examining how the extent and depth distribution of remaining kelp forests varies across environmental gradients can provide valuable insights into the key stressors influencing kelp distribution. Drop-camera surveys were carried out at 102 reefs across Queen Charlotte Sound. Habitat types within each survey photo were classified and used to examine how the depth distribution and prevalence of kelp forests (*Ecklonia radiata* and *Carpophyllum* spp.) related to seawater temperature, turbidity, wave exposure and urchin density. Kelp forests were most prevalent in areas with high water motion and higher turbidity, but urchin barrens dominated more sheltered areas, covering >65% of the reef on average. The prevalence and lower depth limit of kelp was negatively related to urchin density, and positively related to wave exposure. Our results indicated that sea urchins were the most significant stressor limiting kelp forests, and their influence on kelp was moderated by water motion. A sea urchin removal experiment is currently underway to test if sea urchin grazing is the primary factor limiting kelp recovery across the Sound or whether future kelp forest restoration will need to employ more active restoration approaches.

Abstracts

Importance of substrate complexity, snail abundance and exposure on the recruitment success of *Ascophyllum nodosum*.

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The recruitment of new individuals into an existing bed of *Ascophyllum nodosum* is required for population maintenance after disturbances such as storms or ice scour. However, it is known that the spatial distribution of new recruits is not uniform. While small timescale studies have highlighted the importance of individual post-settlement factors on the loss of recently settled zygotes, few large-scale surveys of recruits have been completed. We measured the recruitment of *A. nodosum* in Eastern Canada in the field, alongside wave exposure, predation pressure, tidal height, and substrate type. Abundance of *A. nodosum* recruits decreased with the abundance of their main herbivorous snail. This was observed both within beds, and between larger regions which also differed in substrate type. To tease apart the effect of snail abundance and substrate type on recruitment, a common garden experiment was set-up in two locations. One site was in southwest New Brunswick where the dominant bedrock is a basalt with a complex surface, the other site was in southwest Nova Scotia where the dominant bedrock is a granite with a more uniform surface. After three years, our results indicate that a complex substrate type facilitates recruitment. Deep cracks are thought to provide protection from both wave action and predation during the post-settlement period. Our findings indicate that there are a number of physical and biological factors that drive the successful recruitment of *A. nodosum* in Eastern Canada and suggests that the timescale of population recovery after disturbance could differ greatly between regions.

Abstracts

Kelp and urchin settlement on coralline algal species with implications for kelp forest recovery

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In recent years dramatic shifts from healthy kelp forests to urchin-dominated barrens have become prevalent, severely affecting ecosystems and local economies. While these two ecosystem states are known to differ in coralline community structure, there is a lack of understanding of coralline derived bottom-up controls in these systems. Previous research has demonstrated critical roles of coralline algae in nearshore ecosystems, inducing invertebrate larval settlement and influencing kelp spore settlement and germination, yet coralline algae are incredibly diverse and ecological differences among coralline species are poorly understood. We studied the settlement patterns of red urchins and several common kelp species from the Pacific Northwest on a range of molecularly-identified coralline algal species to better characterize these ecological interactions. Settlement rates of red urchins and juvenile canopy-forming kelp densities did not differ significantly across coralline algal species that were abundant in both kelp forest and urchin barren habitats. This suggests the generality of urchin and canopy-forming kelp recruitment and their ability to recruit into nearshore systems regardless of the coralline composition. However, differences were observed for a sub-canopy kelp species, where settlement was inhibited on crustose species but actively recruited to articulated coralline species, suggesting that articulated corallines typically absent in urchin barrens would need to recover before this sub-canopy species could return. These results contribute to our understanding of kelp forest community assembly and could have important implications for kelp forest recovery following changes in coralline community structure in urchin-dominated barrens.

Abstracts

Restoration of seaweed forests in Korea: a series of experimental works for last 7 years conducted on the urchin barrens habitats

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Deforestation has been a major concern in the Korean coastal ecosystems, and *Mesocentrotus nudus*, the dominant sea urchin species, was regarded as a major cause, appearing >8 inds/m^2 in barren sites. This study was started with testing the various feeding habits of *M. nudus,* followed by field manipulative experiments to examine i) the possibility of seaweed bed recovery by controlling urchin density, ii) the speed of recovery and deforestation in a bi-directional test, iii) the threshold density of sea urchins, and iv) the functional recovery of restored forest. *M. nudus'* most preferred food choice was *Undaria pinnatifida* among the six common seaweed species tested, but the choice switched to *Grateloupia elliptica* depending on their past feeding history. Barren rocks recovered to the level of existing natural forests within 1.5 years by controlling urchin density only, and the effect of further exclusion of other herbivores was not significant in quantitative perspectives. On the other way of phase shift, deforestation took 1.0 year when existing forests were exposed to the urchin density of barren state. The threshold density of *M. nudus* between the two phases was 2.5 inds/m^2 in this study for the case of mostly annual seaweeds with a high seasonality. Regarding the functional recovery measured by trophic structure and food web stability, it took 2 years to reach the nearby natural forest level with the first year of restoration not an intermediate stage toward the completion, but a transient over-shooting state. Conclusive notes and discussion are addressed in the presentation.

Abstracts

Differences in recovered community assemblage depending on the removal of sea urchins and other herbivores, coupled with transplant of *Ecklonia bicyclis*

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Subtidals in the east coast of Korea represent typical urchin barrens with low macroalgal abundance. We investigated the relative effects of grazer control and transplantation on algal forest restoration in subtidal barren rocks in Jangho, east coast of Korea. We set three experimental treatments: no urchins (NU), NU plus no herbivorous gastropods (NH), NH plus *Ecklonia bicyclis* transplant (NHT) in an additive manipulative design. Six months after the initiation of the experiment, seaweed abundance increased in all experimental treatments. The highest peak was found in the spring season of the 1st year. Year-to-year variations became smaller throughout the survey period due to transitions in algal assemblage from fast-growing annuals to perennials. The comparison of NU and control site indicated that urchin removal had an exclusive effect on algal recovery while additional removal of herbivorous gastropods had no effect on quantitative recovery. The community assemblages of the three treatments became more distinct in the subsequent years, showing diverse dominance in NU, red algal dominance in NH, and dominance of *E. bicyclis* and understory groups in NHT. Subsequent demographic studies of *E. bicyclis* showed a continuous increase in population size and number of recruits. Furthermore, dispersal of *E. bicyclis* to surrounding habitats was observed, confirming the successful population establishment from transplantation. Our research provides evidence that 1) urchin removal from barrens can lead to rapid restoration of seaweed forests in subtidal habitats and 2) successful establishment of kelp population functions as a spore source, promoting phase shift from barren to algal forest.

Abstracts

Restorative aquaculture: Quantifying the environmental and social benefits of seaweed farming

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Restoration of declining underwater forests is essential for a sustainable future, but efforts can often be limited in scale. As aquaculture expands globally, and seaweed farming emerges in Australia, it presents an opportunity to employ restorative practices for positive environmental and social outcomes. Restorative aquaculture can help support ocean ecosystem function and recovery while simultaneously providing sustainable sources of nutrition for community and income for farmers. In this way, it is potentially more scalable than traditional restoration-focused efforts under current economic climates. Using a case study of establishing a seaweed farm on an existing oyster lease in Queensland's Moreton Bay (Quandamooka Sea Country), we explore the environmental and social aspects of integrating seaweed onto a small family-owned oyster farm as a 'low hanging fruit' pathway to demonstrate restorative aquaculture. To measure the benefits of seaweed on local marine environments, we needed to create a baseline for biodiversity which was monitored over a year using traditional (photo-quadrats and RUV footage) and novel (environmental DNA) methods prior to, during and following seaweed deployment. The seasonal abundance of seaweed and co-occurring organisms will be presented. To gauge the local community's understanding of and attitudes towards seaweed farming in Moreton Bay we conducted qualitative and quantitative social research with communities, oyster farmers, and the local water utility. The results of these surveys, including links to the environmental data, will be discussed in the context of how at scale restorative aquaculture could provide functional equivalence to natural populations of underwater forests.

Untargeted metabolomics analysis reveals different profiles of *Arabidopsis thaliana* following treatment with seaweed extract

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Seaweed extracts are a prominent class of biostimulants that enhance plant health and tolerance to biotic and abiotic stresses due to their unique bioactive components. In our previous study, it was demonstrated that a single application of seaweed extract induced priming effects on *Arabidopsis thaliana* by altering major plant defence, immune signalling and prime-related genes (Islam et al., 2021). However, the mechanism of how these positive responses are accomplished is still unknown. Hence, in this research, two applications of Seasol Commercial, a seaweed extract derived from *Durvillaea potatorum* and the common brown algae *Ascophyllum nodosum* were used to evaluate further effects on the growth and defence system of the model plants. 14-day seedlings were grown in a sand system and soil-applied with seaweed extract. Root and leaf samples at 0, 3, and 5 days after the last treatment were harvested and extracted. Full-scan data acquisition was carried out using an untargeted ultra-high-performance liquid chromatography (UPLC) combined with high resolution mass spectrometry (HRMS) method to identify a wide range of metabolites. Our study demonstrated that the metabolomic profiles of plants at different time points vary significantly from each other. The significant alterations were mainly fatty acids, carbohydrates, and amino acids. Changes in TCA cycle-related compounds such as malate, fumarate, succinate and important jasmonic acid and salicylic acid-mediated signalling pathways reveal the considerable reprogramming caused by priming effects. The results suggested that seaweed extract promotes plant growth and defence systems by altering various physiological processes at metabolic levels.

Islam MT, Arioli T and Cahill DM (2021) 'Seaweed Extract-Stimulated Priming in *Arabidopsis thaliana* and *Solanum lycopersicum*', *Plants (Basel)*, 10(11), https://doi.org/10.3390/plants10112476

Abstracts

Pathways to function: 'Omics' reveals how seaweed-derived biostimulants enhance plant productivity and reduce biotic stress

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The 'Omics' era presents us with an unparalleled opportunity to undertake deep analyses of the actions and functions of seaweed-derived biostimulants. Our recent work on transcriptomic and metabolomic analyses of plant responses to application of brown algal extracts has revealed an intricately complex mode of interaction. In particular, our discovery of priming or 'ready for action' induction following application of these extracts means plants are better able to respond to stress. We have used extracts derived from the brown algae, *Ascophyllum nodosum* and *Durvillaea potatorum* in studies on the model plant, *Arabidopsis thaliana*, and the horticultural species, *Solanum lycopersicum* (tomato) and *Castanea sativa* (sweet chestnut) to explore priming with or without infection by the pathogens, *Phytophthora cinnamomi* and *Gnomoniopsis smithogylvii*. We have shown a strong priming response following seaweed-extract application that included the upregulation of reactive oxygen species that are required for many important signalling reactions. Priming and defence priming-related genes were also upregulated prior to pathogen infection. Coupled with the striking upregulation of major genes related to plant defence such as the 'pathogenesis related' (PR) genes we found key metabolites such as the phytohormones salicylic acid and jasmonic acid and those related to primary and secondary metabolism to be increased in abundance following extract treatment. Further, the finding that seaweed extracts stimulate gene activity and metabolite production in Arabidopsis related to both photosynthesis and energy production, presents a platform of induced change that can be manipulated in crop species for stress resilience, enhanced growth and a boost in productivity.

Abstracts

RNASeq analysis of Seasol treatment of growth media on the lettuce seedling root transcriptome.

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Seasol is a liquid plant supplement made from Bull Kelp (*Durvillaea spp*) and Knotted Kelp (*Ascophyllum nodosum*). A standard dilution of the commercial product was used to treat a commercially available seedling raising mix prior to sowing of lettuce seed. Compared to the water treated seed raising mix, an increase in seedling emergence was observed for plants sown in the Seasol treated growth media at 4 and 5 days after sowing. Leaf lengths were measured weekly for 3 weeks post planting, with these being statistically longer (p value of t-test <0.05) for all three weeks in the treated plants. To gain a molecular understanding of possible reasons for the enhanced emergence and shoot growth, root samples were used for RNA sequencing at the 21day timepoint. Comparisons between the transcriptomes of Seasol treated lettuce plants and the controls revealed that genes involved in the lettuce plant's nitrogen metabolism were up-regulated in the Seasol treated plants. The results from a more detailed time-series RNAseq experiment will be presented, including an analysis of the microbiome differences between the Seasol treated and un-treated lettuce roots.

Abstracts

Evaluating the phytotoxicities of two Irish red seaweeds against some common weed species

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Synthetic chemical herbicides available to farmers and foresters are known to be hazardous, and their overuse, without possible alternatives, have resulted to weed species developing resistance.

From a phytotoxic screen against *Lactuca sativa* (lettuce) seeds, the ethyl acetate extract of two Rhodophyta species, *Mastocarpus stellatus* (MEE) and *Porphyra dioica* (PEE) were found to be most active in reducing lettuce seedling growth. Through conducting pre- and post-plant emergence assays in lab trials, the phytotoxicities of both extracts were further evaluated against weed species: a broad-leaf weed, *Trifolium repens* (wild white clover) and a grass, *Lolium multiflorum* (Italian ryegrass). At 5 mg/ml, MEE produced stronger pre-emergence phytotoxicities than PEE, significantly inhibiting seed germination and seedling growth of white clover by 77.3% and 97.2%, respectively, compared to the solvent control. For ryegrass seeds, comparing the phytotoxicities of both extracts to the solvent control, MEE inhibited germination and seedling growth by 30.2% and 66.8%, respectively, whereas PEE inhibited seedling growth by 21.1%, but had no inhibitory effect on germination. On the other hand, the post-emergence assay revealed stronger phytotoxic activities for PEE at the same concentration (5 mg/ml). The overall growth of ryegrass and white clover plants, respectively, were reduced by 42.7% and 35.6%, due to PEE treatment, and 13.5% and 30.0%, due to MEE treatment, in comparison to the solvent control.

These findings are indicative of the presence of phytotoxins in MEE and PEE, and could possibly lead to the development of greener and sustainable bioherbicide sources, to replace or augment synthetic herbicides

Abstracts

Effect of seaweed extract on avocado root growth, yield and post-harvest quality in Queensland, Australia

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Seaweed extracts are proven to increase productivity in many agricultural crops, but there is limited research on their use in avocado production. Therefore, we evaluated the effectiveness of a seaweed extract from *Durvillaea potatorum* and *Ascophyllum nodosum* on avocado yield, revenue and post-harvest fruit quality in a series of field experiments in Australia, and on seedling root growth in a pot experiment. The field experiments were conducted on commercial farms across three different locations in northern Queensland over four years and utilised avocado trees with different ages, cultivars (Hass and Shepard) and inoculum pressures from *Phytophthora cinnamomi*. Results showed that the application of the seaweed extract by fertigation significantly improved avocado yield (kg fruit per tree) by 38%, fruit firmness by 4% (skin) and 22% (flesh) and fruit skin colour by 1° (hue), and an upgraded visual ripeness score. The increases in yield were associated with greater number of fruits per tree (up to 42%) indicating the liquid seaweed extract improved fruit set and retention per tree. Regular soil application of the seaweed extract to young trees (cv. Hass) in pots increased the root fresh weight by 22%. Overall, the regular application of the seaweed extract to avocado trees was found to be practical and economically viable for improving fruit production and post-harvest quality in Australian orchards.

Abstracts

The competitiveness of Indonesia's seaweed products in the international market

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The seaweed industry increased rapidly in Indonesia in the 21st century and boomed in production since 2012. Indonesia is currently the second largest seaweed producer in the world with share production of worldwide around 30%. Indonesia as an archipelago country has the potential to improve seaweed production and export in the global market. This research aims to overview the competitiveness of Indonesia's seaweed in the international market, including dried seaweed and processed seaweed and compare the competitiveness of seaweed with the main exporters worldwide by using the international market share index (IMS), the trade competitiveness index (TC), and revealed comparative advantage index (RCA) from 2012 to 2021. Based on the result of Trade Competitive Index shows Indonesia has strong comparative advantage for almost every product, except HS 130231 as moderate comparative advantage. For RCA analysis shows that all seaweed product has a strong comparative advantage, the most interest thing is RCA for processed seaweed had lower value than dried seaweed. It is indicated Indonesia has potentially to improve processed seaweed product. Furthermore, this paper also analyzes determinant factor of seaweed export by using gravity models. The results show that GDP per capita of country destination, Real Exchange Rate, and Distance has a significant effect on export dried seaweed. while for processed seaweed, the determining factors of export are price and GDP per capita.

Abstracts

Tropical seaweed extract based agro bio-stimulant 'SAGARIKA' in combination with nano urea for better crop health and higher crop production in rice

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Seaweed extract based agricultural bio stimulant that are currently available in the market, are manufactured mainly from brown seaweeds of cold water origin. 'SAGARIKA' a seaweed extract based product of 'AquAgri – IFFCO Bazar' is a tropical seaweed based agricultural bio-stimulant manufactured from Kappaphycus alvarezii and Sargassum species. Nano-urea, the novel product of IFFCO in combination with Sagarika was found to have better crop production in rice. A trial was conducted some varieties of rice being grown in different climatic condition of India recording 26.5% higher crop yields as compared to the yield obtained through application of standalone. SAGARIKA is a repository of micro and macro-nutrients, plant growth regulators (PGR) such as Auxins, Cytokinins and Gibberellins. In addition, it is also a source of thermo-stable glycine, betaine and choline which help boost crop yields, through activation of its internal metabolic processes. Basal application of SAGARIKA granule (@25 Kg/ha) and foliar application of SAGARIKA liquid (@ 0.25 %) at critical crop growth stages has become an integral part of balanced soil- crop nutrition programme. It has resulted into yield enhancement to the tune of 9.5 to 36.0% in different varieties of rice. SAGARIKA-Nano urea blend has also led to improvement in crop immunity and its tolerance to various biotic – abiotic stresses. Present investigation summarizes its production, nutrient profiling and constituent details as well as its efficacy trial results in different crop geographies. Authors have also attempted to focus on its stress relieving properties and mechanism of action in plants.

Abstracts

Critical considerations for building a regenerative seaweed value chain

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As the world struggles with pessimistic outlooks for climate and biodiversity, seaweed is increasingly presented as a refreshing, positive opportunity for industry to deliver for the 4Cs of Community, Conservation, Commerce and Climate. The most cultivated seaweeds globally, the eucheumatoids, are particularly significant as they are grown primarily by marginalised coastal communities in the global south facing the brunt of the climate and biodiversity crises. However, there is growing concern around the sustainability of eucheumatoid production that has led major brands to adopt sustainability commitments, and marine conservation groups are increasingly assessing whether promotion of seaweed projects are delivering biodiversity gains. Here, we present data that shows that the promotion of seaweed farming has historically done very little to prevent continued loss of marine biodiversity, and in the majority of cases has actually increased threats to and pressure on marine biodiversity. Utilising a mixed methods approach, we identify the key drivers for these outcomes, and demonstrate that there are entry points for creating regenerative seaweed value chains. Finally, we present a blueprint for what it would take to create a truly regenerative seaweed value chain that delivers for the 4Cs. We argue that it is imperative for the seaweed revolution to learn from the mistakes of 'business-as-usual' agri-development pathways so that it may become the foundation for an inclusive and sustainable blue economy.

Abstracts

Seaweed cultivation in Madagascar – Developing an aquaculture model based on risk mitigation approach and coastal communities to ensure a growing and sustainable seaweed supply chain.

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After several years working in the industry, sourcing seaweed all over the world, it became clear that there was a need to modernize seaweed production and turn around current supply chain to sustain the activity and accelerate the development of new markets thanks to seaweed great potential. Tropical seaweed supply nowadays remains scarce, cultivation techniques have not evolved since it started in the late 70's and farmers are becoming more and more vulnerable because of climate change.

To develop a thriving sustainable seaweed industry, we are implementing, in Madagascar, an aquaculture model where risk management, modern thinking and social dimension drive our decisions and the way we shape the activity.

The result of this approach is a disruptive model combining craftmanship, improved or novel cultivation techniques, technology, research, multiple collaborations and proximity with coastal communities we are working with. We believe this model is fair and will handle better future turbulences. We also think it is an attractive option for all and could serve as a reference for future developments and deserves to be shared to contribute to the seaweed revolution.

Abstracts

Status and requirements in the genetic diversity of commercial eucheumatoid industry

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Eucheumatoids are phycocolloid-producing seaweeds from the family Solieriaceae (Gigartinales, Florideophyceae). They are the major source of carrageenan, a hydrocolloid that has been utilized in the industrial, pharmaceutical, cosmetic and food industries for decades. Philippine eucheumatoids have been farmed for more than half a century. Throughout this long history, cultivars have been developed and distributed worldwide. Eucheumatoids are morphologically plastic and are oftentimes misidentified. Thus, genetic data is very important in confirming species identities. Moreover, recent genotyping studies based on the concatenated COI-5P and cox2-3 spacer sequences revealed rich genetic pool. However, only a few haplotypes are currently being farmed. The vegetative propagation in seaweed mariculture ensures the preservation of desirable traits and safeguards the quality of the farmed cultivars, but negates genetic exchange over time that leads to low genetic variation and decline in plant vigor. High genetic variation enables growth in wide range of environmental conditions especially in a changing climate. To provide alternative and resilient seedstocks for the commercial cultivation, a sectorial and multistakeholder approach is required to ensure the development of adequate breeding and nurseries facilities as well as a model that will facilitate the fair accessibility of high quality seeds to farmers.

Abstracts

Conservation International Ventures and Konservasi Indonesia presents the Coral Triangle Seaweed Strategy – unlocking benefits for people and planet across the value chain.

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Conservation International Ventures is a philanthropically capitalized, impact-first, venture fund – seeking to provide flexible financing for startups in emerging markets pioneering solutions that benefit people and planet. CI Ventures is working with the Global Fund for Coral Reefs, a blended finance instrument to mobilize action and resources to protect and restore coral reef ecosystems, to develop sustainable alternative livelihoods within the Coral Triangle through seaweed farming.

The MMAF have targeted a 25% increase above 2019 seaweed production volumes by 2024, with a large proportion of growth expected from existing and new farming areas within NTT. To meet these targets, MMAF have announced plans to develop a network of "seaweed villages" across Eastern Indonesia, with East Sumba as one of two inaugural priority sites being launched in 2022. The government's "seaweed village" strategy advocates for a holistic approach to sector development, linking private companies, funding institutions and a range of "stakeholders including the government, academicians, business operators, media and the public.

Our team is working to build a more robust understanding of the underlying factors that influence seaweed cultivation and management behaviors through a series of landscape assessments; socioeconomic, industry and commercial, and environmental baseline assessments. These research activities are expected to strengthen the foundation for meaningful program interventions and investments that align reef protection and economic incentives through:

1) directly addressing local and industry-scale drivers of reef degradation;

2) generating meaningful, durable reef-positive income, livelihood, and employment benefits;

3) achieving broad-scale impact through business model replication or commercial scaling

Through first addressing fundamental science, data and information gaps related to coral reef-macroalgae farming interactions, we can then deploy funding into the interventions across the entire value chain most effective in promoting sustainable and equitable growth of the Indonesian seaweed industry. By the time of the International Seaweed Symposium, the three landscape assessment studies will be 50% complete, and we will be able to comment on progress to date, discuss coral reef-macroalgae impact indicators, map out key interventions across the seaweed value chain, as well as share progress from current investments in the sector.

Abstracts

Technology gaps, innovation opportunities and new markets for a productive and scalable eucheumatoid seaweed industry - Insights from Hatch's global seaweed report

Author: Hatch Blue with funding from The World Bank Group and The Nest Family Office

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The single-market reliance of tropical seaweeds farmed in the Philippines, Malaysia and Indonesia brings volatility to the supply and demand of raw dried seaweed, while market research and connectivity to non- hydrocolloid markets is limited. As part of our assessment of the global seaweed production status and market opportunities, Hatch has conducted in-field research across the major seaweed producing regions in these countries and gathered data across the supply chain. Between May and August 2022, we visited and interviewed farmers, local collectors, traders, exporters, processors and ingredient manufacturers and received valuable first hand information on volumes and price trends of the seaweed biomass from the established seaweed farming regions. By analyzing the challenges of farmers and other value chain players this work outlines technology gaps, innovation opportunities and investment needs. Matched with an in-depth analysis on novel products and applications, it further provides an outlook on new market opportunities for the seaweed biomass.

Abstracts

The connection between seaweed farming practices and local marketing systems and financial services in two Indonesian villages

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The Indonesian seaweed industry has grown rapidly over the last twenty years and is largely focussed on the marine cultivation of carrageenan seaweeds. Smallholder farmers dominate the production sector, and these farmers operate in diverse agro-climatic and socio-economic settings. The industry faces issues with inconsistent seaweed product attributes linked to low price-grade differentials. This paper examines how local seaweed marketing systems affect farmer production and post-harvest handling behaviour in two villages in South Sulawesi. It draws on a household survey of 273 seaweed farmers and extensive qualitative research undertaken by four of the authors over twelve months. We show that there are substantial differences in seaweed marketing and farmer access to financial services both between and within study locations. This results in different seaweed production and handling behaviour, leading to different forms of integration into broader seaweed value chains.

Abstracts

The Sinofication of global carrageenan seaweed processing and implications for Indonesia

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In just 20 years China has risen to lead the global carrageenan processing sector with wide-ranging implications for the global seaweed industry. This is especially the case for Indonesia, the largest red seaweed producer in the world that exports almost all seaweed to China and where Chinese investment accounts for up to half of Indonesian processing throughput. Even though China has reconfigured the global carrageenan value chain, there is a dearth of studies on the topic. This study fills the gap by triangulating detailed trade, industry and Chinese-language data, and outlining the implications for the Indonesian carrageenan seaweed industry.

Underexploited potential of the seaweed aquacuture in the non-asian Indo-Pacific region

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Large-scale seaweed aquaculture has been a common practice and valuable source of income for centuries in Asia, but the potential is comparatively underexploited in the rest of the Indo-Pacific region. Over the past few years, Australia and New Zealand have developed significant expertise, raised substantial funds, and launched a national alliance to stimulate the industry in various sectors, including human, animal, and plant nutrition or environmental remediation. Elsewhere in the region, the tropical seaweed industry is poorly developed and fragmented. Seaweed productions consist mainly of the introduced Kappaphycus and Euchema for the carrageenan export market or a few species traditionally harvested for food. Recently however, several new projects are emerging, from transforming overgrowing Sargassum into fertilizers in Seychelles to cultivating Mozuku (Cladosiphon) in Tonga, feeding cows with Asparagopsis in Hawaii, or growing Caulerpa in French Polynesia. However, despite the rising interest in seaweeds globally, regulations and standards about the safety of seaweeds for human consumption, animal feed, or fertilizers are still very poor and are virtually non-existent in tropical regions. Funded by the Safe Seaweed Coalition, the SouthPACIWEED project is i) reviewing existing regulations and identifying gaps, ii) assessing risks associated with seaweed consumption and producing new data to provide a regional baseline (heavy metals, pollutants, iodine), and iii) establishing a regional working group that will work cooperatively to address the safety issues and lack of standards that may hinder the development and diversification of the seaweed industry regionally.

Abstracts

SecureFuture: Selection and curation of safe and healthy eucheumatoid seedlings for the future

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Most eucheumatoid cultivars used by seaweed farmers have been vegetatively propagated since the 1970s. Vegetative propagation from cuttings provides benefits by ensuring genetic uniformity and consistency in quality, and avoidance of cost associated with sexual reproduction. However, clonal propagation is also detrimental to fitness making the entire cultivar more susceptible to disease due to lack of genetic variation. The University of the Philippines Marine Science Institute (UPMSI) is holding culture collections of different strains/ cultivars of eucheumatoid at the Seaweed Culture Laboratory and Gene Bank (SCL&GB) and at the Bolinao Marine Laboratory (BML) outdoor land-based nursery (OLBN). Most of these are wild parental strains and their progenies, and some commercially cultivated strains. However, the collection, collation and maintenance of these assets are costly, and time and labor intensive. Hence, the genetic characterization and biobanking of different commercially cultivated and wild indigenous cultivars, production of F1 generations from reproductive plants, and their physiological and biochemical characterization were made possible through funding from different local (Institutional and University grants), national (CHED-LAKAS) and international (e.g., GlobalSeaweedSTAR, Sea6Energy, and Safe Seaweed Coalition) research endowments. In partnership with the social enterprise Coast4C and other partner seaweed farmers, they receive promising new cultivars for sea-based grow out and evaluation in their community-based nurseries that will eventually provide seedstocks for distribution throughout their growing network of seaweed farmers. Furthermore, in discourse with different stakeholders (e.g., the academe, R&D, NGOs, and processors), we are consolidating a Southeast Asian coalition to establish a regional eucheumatoid initiative responsible for the development of high quality and resilient seedstocks and the inception of a model that will facilitate their fair accessibility to farmers to boost global eucheumatoid production to meet the increasing demand for high quality biomass for various industrial applicati

Abstracts

Seaweed Aquaculture – The Opportunities for Tasmania and Australia

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Almost every day there is a new report about the benefits of seaweed, consequently seaweed aquaculture is gaining increasing attention both globally and in Australia. In 2018 global seaweed aquaculture production was approximately 32.4 million tonnes (97% of all seaweed production), this is now around 35 million tonnes, and expected to increase markedly in the next few years. This has resulted in significant public and private investment in seaweed aquaculture research. In Australia, the recent establishment of the Blue Economy CRC and the Marine Bioproducts CRC has provided more than $120M for research specifically focused on supporting the development of viable marine aquaculture industries. However, to really target research in areas where seaweed aquaculture has most potential it is important to understand the market opportunities and the economic viability of seaweed aquaculture. In this presentation we will summarise the findings from a project undertaken to identify specific markets, and consumer and product expectations for three kelp species currently being grown in Tasmania. The results provide important insights into market opportunities, product expectations, and the production and business models required to ensure a viable industry. The findings show a number of very promising seaweed product opportunities, but that further research is needed to provide the detailed understanding to optimise those opportunities and establish a viable bioeconomic model for seaweed production in southern Australia/ Tasmania.

Abstracts

Optimising the zoospore release, germination, development of gametophytes and formation of sporophytes of *Ecklonia radiata*

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The kelp *Ecklonia radiata* has become a target for controlled cultivation. However, to date, there are no standardised protocols for the hatchery stage of this species that result in high rates of germination, gametophyte development and transition to sporophytes. Therefore, the objective of this study was to quantify the effect of photoperiod, light intensity, temperature, nutrient media and use of GeO_2 on the key hatchery processes of germination, gametophyte development and transition to sporophytes in controlled laboratory experiments. Germination of *E. radiata* was high (≥ 70%) throughout the study, regardless of treatments. Temperature had a major effect on the length of gametophytes, which increased with increasing temperature. The formation of sporophytes was favoured when individuals were maintained under 17°C continuously, but was reduced by approximately 30% when using F/2 compared to PES nutrient media. Overall, the recommended conditions for the hatchery stage of *E. radiata* are to maintain cultures under a 12 h L:12 h D photoperiod at 17°C as this resulted in higher germination rates, good gametophyte development and higher transition to sporophytes compared to other treatments. Moreover, the use of GeO_2 has to be limited to no more than 2 days as extended use has detrimental effects on the development of sporophytes. Finally, storage of sorus-bearing fronds of sporophytes up to 4 days after the collection from the field generally increased the number of released zoospores and is a simple mechanism to increase the fertility of brood stock

Abstracts

European seaweed cultivation: optimising seeding techniques for *Saccharina latissima*

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The cultivation of macroalgae is an emerging field across Europe, driven by a wide range of applications. However, commercialisation is impeded by high laboratory costs associated with traditional twine seeding. The recent development of a 'bio-binder' allows direct seeding onto cultivation lines followed rapidly by deployment. This can reduce production costs, bypassing the lab grow-out stage necessitated by twine seeding, but requires validation at sea.

We compared the success of twine seeding with two direct seeding methods using a *Saccharina latissima* gametophyte suspension applied at a standardised density of 2.45 mL m^{-1}. Spools of twine were inoculated with meiospores and tank cultured for 7 weeks, after which twine was coiled around cultivation lines for deployment. A 'one-stage' direct technique involved mixing gametophytes and bio-binder solution together prior to application onto cultivation lines, while a 'two-stage' technique involved application of gametophytes to lines prior to coating with bio-binder. Once seeded, lines were deployed at sea as 6m long 'droppers' at a mixed seaweed and mussel farm in Cornwall, UK, for eight months.

Preliminary results indicate that success of direct seeding is inter-annually variable. Seeding method has a considerable effect on yield, morphology, and density of both *S. latissima* and non-target *Saccorhiza polyschides,* which settled on lines from adjacent wild populations. Further, reduced yield of *S. latissima* is correlated with increased abundance of *S. polyschides* at deeper depths, and from direct rather than twine seeding. These initial findings have the potential to progress the nascent European macroalgal cultivation industry towards commercialisation.

Seasonal and site-specific differences in growth and sporophyte production of *Ecklonia radiata* gametophytes

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The brown seaweed *Ecklonia radiata* (Order Laminariales) is a candidate for aquacultural cultivation in southern Australia, but we know little about the microscopic life stages compared to macroscopic sporophytes. This study uses thermal response curves (4 °C to 30 °C) to examine the effect of season on temperature optima for gametophyte growth and subsequent sporophyte development, for *E. radiata* from two sites that have different seasonal temperature profiles and hydrography: north-eastern Tasmania (12.4 °C to 17.4 °C) and south-eastern Tasmania (11.6 °C to 16.7 °C) the former experiencing higher temperatures and for longer periods. Gametophytes were cultured for 6 weeks in each of 4 seasons, in a temperature gradient table. Gametophyte size was recorded after 4 weeks, and sporophytes production after 6 weeks. The thermal response curves showed temperature optima for gametophytes around 20 °C for spring, summer, and autumn (winter experiment ongoing). We observed clear differences in gametophyte size between the two sites in spring, with the northern site growing substantially larger, but this was not observed in summer or autumn. Sporophyte density was generally low (< 0.4 mm^{-2}) with no site consistently producing more sporophytes. Temperature optima for sporophyte production lay between 15 and 17 °C at both sites. The results inform the best times to collect reproductive material to set up stock cultures for aquaculture as well as optimal temperatures for culture growth.

Abstracts

Effect of growth parameters on *Macrocystis pyrifera* (giant kelp) sporophytes for bioproduct production

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The application of seaweed-derived bioproducts in pharmaceuticals, foods, dietary supplements and functional foods has accelerated in recent years. Sustainability of seaweed supply is crucial to ensure growth of this industry and the blue Bioeconomy. Presently, 94% of the annual seaweed biomass used globally is cultivated from 10 seaweeds but *Macrocystis pyrifera* (Giant Kelp) is not one of these. Seaweed based dietary supplements are in more demand than ever, especially those that include essential, (omega-3 (ω-3) and omega-6 (ω-6) polyunsaturated fatty acids (PUFA), as they are associated with prevention of inflammation and cardiovascular diseases. *Macrocystis pyrifera* cultivars from Tasmania (UTAS, supplied 2020) were cultivated at laboratorty/hatchery scale at temperatures ranging from 12-18°C. Results found that sporophytes grew best at 12°C in 12/12 light/dark (L/D) conditions as opposed to 16/8 L/D. Photo irradiance was 30 μmol m^{-2} s^{-1}, using F/2 media, with moderate tank aeration. The optimal cultivation time was 45-58 days to produce sporophytes of 4-5 mm in length. Nutritional composition noted that 12°C (12/12) had 12 ± 0.75 % W/W total polysaccharides and 0.4 ± 0.07 % DW sulphated polysaccharides, these results were significantly higher than the other treatments, 15˚C (12/12), 12˚C (16/8), and 18˚C (12/12).The highest protein content was 22.48 ± 1.80 % DW, for 12˚C (16/18) treatment. The composition of total fatty acids (TFA) included 47 % essential fatty acids (EFA) for 12˚C (12/12), 39% for 12˚C (16/8), and 45% for 15˚C (12/12). These results indicate that optimal hatchery-scale cultivation conditions may influence specific bio-product development

Abstracts

A comparison of novel seeding approaches for upscaling Giant kelp (Macrocystis pyrifera) cultivation

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The utilization of novel seeding techniques can reduce the economic barriers associated with upscaling kelp aquaculture in the United States. The traditional method of twine seeding is labor intensive and requires a large hatchery footprint when compared with direct seeding. Direct seeding involves the binding of gametophyte and or juvenile sporophytes onto a substrate (i.e., rope) for later out planting, requiring far less labor and hatchery space. For the first time, we use a direct seeding approach to cultivate Giant kelp (*Macrocystis pyrifera*) in Southern California and compare three methodologies that have the potential to reduce labor and improve the efficient use of seed stock. In this study we propagate and seed nylon ropes with a collection of locally sourced gametophytes and compare a hand massage seeding technique, a mechanical two-step direct seeding approach and a mechanical interval spot seeding approach. Both mechanical methods utilize the novel Seawiser seeding machine. Using a partial factorial design, we assess long-term differences in biomass between a traditional twine method and the three direct seeding methodologies. All direct seeding methodologies produced viable seedlings and we observed no difference in long-term success of the twine, massage, two-step, and spot seeding techniques. These results support the efficacy of using a direct seeding approach to cultivate Giant kelp and suggest machine seeding is the most efficient methodology based on labor-time comparisons. Future work should focus on fine tuning the seeding machine, with an emphasis on spot seeding to further optimize efficient use of seed material.

Abstracts

The effects of mechanical harvesting on *Ascophyllum nodosum* and associated invertebrates

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Ascophyllum nodosum (L.) Le Jolis dominates the rocky intertidal zone across most of its distribution in the North Atlantic and is widely harvested at a commercial scale in North America and Europe. Common harvesting techniques are a walk-on harvest using a knife, a specialized manual cutting rake from a boat, and mechanized vessels with hydraulic cutter heads (mechanical harvesters). The walk-on harvest and mechanical harvesters traditionally conduct a pulse harvest at higher exploitation rates than the boat and rake. After the harvest, beds are left fallow for multiple years to regrow. To examine *A. nodosum* recovery rates and the impact on associated invertebrate communities following a mechanical harvest, we established two control and two experimental harvest plots at two sites in Maine (USA) in August 2018. A second harvest was conducted in 2021 to reproduce a three-year pulse harvest. Data collection on *A. nodosum* and invertebrates (second harvest only) was collected prior to harvesting, immediately post harvesting, and at one-year intervals for three years. The harvests removed 53% and 41% of the *A. nodosum* biomass respectively, resulting in a significant decrease in biomass and length but no difference in snail populations. The impact of the harvest was short, after one year there was no significant difference between our control and experimentally harvested plots for biomass or length. Our initial results indicate that the impact of mechanical harvesting has only a short-term impact on *A. nodosum* architecture. Further results will provide data on the effects of a repetitive mechanical harvest.

Abstracts

Biorefinery of *Ulva spp.* and evaluation of food quality of resulting protein concentrate

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Sea lettuce (*Ulva* spp.) harvested in a Danish Fjord was processed in lab and pilot scale. The main goal was to extract protein from the biomass and evaluate it according to yield and food quality. The biomass crude protein content ranged between 6 and 20% of dry matter, concentrating up to 4-fold upon processing with double screw pressing followed by acid precipitation and centrifugation in pilot scale. Depending on season, the protein concentrate showed between 40 and 50% protein of dry matter. Washing of the biomass before processing lowered the ash content in the protein concentrates. The protein concentrates from the pilot study were evaluated in relation to functional properties and in meat analogues in combination with pea protein isolate (PPI). Solubility, foaming and gelling of *Ulva* protein fractions and PPI were investigated at food relevant pH conditions and a salt concentration of 0.2 M. Solubility of all protein fractions was low (< 20%) but alkaline pH-shift increased the solubility significantly. Depending on the pH, the foaming capacity was either significantly lower or higher, when compared to control. In general, the foam stability increased for PPI and *Ulva* fractions after alkaline pH-shift. Gelling properties of *Ulva* protein were assessed at 10% and 30% substitutions in 20% PPI gels. Rheological measurements revealed significantly increased gel strength and stability at 10% substitution. At 30% substitution, gel strength increased significantly but stability decreased. However, the processing needs further improvement for utilising the biomass for food.

Protein extraction increases the N digestibility of sea lettuce protein

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Sea lettuce (*Ulva* spp.) is gaining interest as a potential protein source. However, knowledge on the nutritional quality, especially protein digestibility and bioavailability, is limited. This study is the first to test the *in vivo* N digestibility in a monogastric animal model. In July 2020, *Ulva* was harvested from Skive fjord (Denmark) and protein was extracted in a pilot-scale facility. The protein was extracted by double screw pressing and the protein was acid-precipitated from the resulting juice. The N digestibility of the crude biomass and of the extracted protein fraction was tested in rats. The extraction of protein increased the N digestibility with app. 20%, however, the N digestibility was still poor (55.5±2.7%). This was possibly due to a high ash content in the protein extract. Hence, further improvement was needed for an acceptable N digestibility. Therefore, in August 2021, the harvest was repeated, and the processing was optimized by including a biomass rinse step prior to screw pressing and a decanting step of the juice after pressing to reduce the amount of sediment/ash in the final protein extract. This resulted in a protein extract (dried) with a crude protein content of 41.2% and an ash content of 24.2%, whereas the protein extract from 2020 had a crude protein and ash content of 28.1% and 38.8%, respectively. It is hypothesized that the increased protein concentration in the 2021 protein extract will further improve the N digestibility of the *Ulva* protein, which is tested in a rat trial in November 2022.

Valorization of *Ulva* sp. for production of fungal biomass protein using *T. reesei*

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Green macroalgae have an interesting nutritional profile that can be exploited for production of feeds and in some times, their accumulated in eutrophicated coastal waters has negative ecological and economic impacts. Therefore, bioconversion of these macroalgae by microbial fermentation allows the production of microbial biomass protein. This research aimed to study the saccharification and fermentation of *Ulva rigida* by a cellulolytic fungus to provide a product with a nutritional added-value. For this purpose, *Ulva rigida* was directly saccharified and fermented in batch using the filamentous fungus *Trichoderma reesei Rut-C30*. The fermentation product obtained from the growth of *T. reesei Rut-C30* on *Ulva rigida* as the sole carbon source in 72 h was called fungal biomass protein (FBP), which contained all essential amino acids and compared favorably with the FAO guideline profiles. Furthermore, the content of limiting amino acid methionine of FBP from Ulva rigida increased 4-folds compared to the raw macroalga and it was similar to the methionine levels of ovalbumin protein. Additionally, the in vitro digestibility of FBP increased from 71% to 94% compared to the raw alga and was higher than that of leguminous seeds and similar to that of soybean meal. The results of our work demonstrate that Ulva rigida can be saccharified and fermented in a single step by a terrestrial fungus in 72 h under submerged fermentation to provide high-quality proteins suitable to produce feeds.

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Abstracts

Why do young adults eat seaweed? An Australian case study

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Seaweed is still not commonly eaten in Western societies, despite the science detailing nutritional benefits, sustainability advantages over terrestrial crops, and economic potential. In contrast, consumers are rarely considered in contemporary seaweed research. Here we explore the motivations that drive young Australians to eat seaweed to better understand and advise seaweed aquaculture development, wild-harvest practices, industry food product development and consumer marketing strategies. An observational cross-sectional online survey with 1,403 young (19-30 years) Australian seaweed consumers was conducted to explore these drivers. The 19-item survey incorporated closed-ended, open-ended and Likert-scale responses, and was based on validated tools developed and piloted specifically for this study. Findings were reported as descriptive statistics, utilizing Pearson's Chi-square where appropriate. Most respondents were female (89.0%), with tertiary level education or above (57.7%), and resided in a metropolitan area (78.0%), consistent with previous literature. Seaweed was most eaten as a snack (87.7%) and in home-prepared meals (30.7%). Key advantages to consumption were flavour (89.1%), nutrient content (49.1%) and health benefits (44.6%), whilst key barriers were lack of accessibility (59.5%), unaffordable pricing (46.5%) and undesirable packaging (19.0%). Consumers reported wanting more promotion and marketing to improve their knowledge regarding seaweed, in addition to environmentally sustainable options for packaging and sourcing. Pathways to overcome barriers and to encourage greater seaweed consumption will be discussed. Most critically, improving the promotion and environmental sustainability of seaweed products is needed to improve intake amongst current and future consumers. Increased consumption could in turn drive nutritional and environmental benefits associated with seaweed.

Abstracts

Algae for novel and healthy pasta

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The importance of nutrition in the prevention of chronic diseases requires the search for new food ingredients of natural origin that promote health and enrich the human diet with vitamins, minerals, fibers and polyunsaturated fatty acids of sustainable origin. Pasta is a nutritious option appropriate for incorporation of these ingredients, since they respond to the food consumption trends of easy preparation, parallel to the fact of presenting complete nutritional quality to the general consumption needs. In this work, an innovative range of dry pasta incorporating algae (*Chlorella* sp. and *Gracillaria* sp.) was developed, to encourage adequate food consumption and consequent improvement of nutritional status of citizens, with a direct impact on the prevention of chronic pathologies and on improving the consume welfare.

After developing the algae-enriched products, a sensory analysis was performed to find the best formulation. Then, protein, vitamins and elements content were assessed. Pasta with algae provided high mineral and vitamin contents, so that could bear nutritional claims: vitamin A (155.54µg/100g), vitamin B1 (0.18mg/100g), vitamin B12 (1.09µg/100g), zinc (1.58mg/100g), selenium (9.48mg/100g), phosphorus (209.68mg/100g), iron (4.64mg/100g), iodine (3.1mg/100g)[1][2]. The addition of algae also allowed to obtain 9.21g of protein/100g pasta.

Additionally, consumer liking of different sensory attributes was measured. Appearance, colour, texture, odour and taste were assessed by consumers, using a 7-point hedonic scale with extremes ranging from "really disliked" and "really liked".

Besides the nutritional potential, the developed pasta also showed very good overall sensorial acceptance and purchase intent prevailed in scores 5 and 6 (35% in both).

[1] Regulation (EC) N◦ 1924/2006 OF THE EUROPEAN PARLIAMENTE AND OF THE COUNCIL of 20 December 2006 on nutrition and health claims made on foods.

[2] Regulation (EU) N◦ 1169/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2011 on the provision of food information to consumers.

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Proximate composition and sensory evaluation of noodles fortified with green seaweed, *Caulerpa lentillifera* powder

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Caulerpa lentillifera has gained popularity among consumers and researchers in recent years due to its intriguingly good nutritional profile. In Asian countries, it is commonly consumed directly, usually in salads and pickles. The objective of this study is to explore whether the fortification of different levels of *C. lentillifera* powder (CLP) concentration in noodles could potentially improve its nutrient profile. The sensory attributes and the nutrient content of the developed noodles were evaluated. Five formulations of noodles containing different percentages of CLP, 0% (F1), 2.5% (F2), 5.0% (F3), 7.5% (F4), and 9.0% (F5) were developed. A sensory evaluation based on a hedonic scale involving 50 untrained panellists was conducted to determine the best formulation of noodles fortified with CLP. All formulations were subjected to proximate and mineral analyses. From the sensory evaluation, the noodle with the best formulation was F2 (2.5% CLP) as it has the highest score in all sensory attributes tested among all formulations with CLP. The incorporation of 2.5% CLP increased the mineral and protein content of the noodles significantly at $p< 0.05$. In conclusion, CLP incorporation in noodles improves its nutrient profile, and the sensory attributes of noodles containing 2.5% CLP were found to be acceptable.

Abstracts

The effect of iodine reducing processing methods on the sensory profile of *Saccharina latissima*

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Processing methods such as blanching have been reported successful in reducing the iodine content of S. *latissima,* which is identified as one major food safety concern in the European seaweed chain. However, such processing is associated with loss of other compounds, among these flavour-active molecules known to provide kelp with its characteristic flavour and taste and their loss may limit food applications. In this study, three different methods to reduce iodine in fresh S. *latissima* were tested and compared: steam treatment and blanching in freshwater and seawater. Blanching in freshwater and seawater reduced the iodine content by 72.6 and 58.6 % on dry weight basis, respectively. Freshwater-blanching resulted in a greater reduction in total dry matter and loss of water-soluble components, mainly reducing the content of ash and carbohydrates. Steam treatment was less efficient and only reduced the iodine content by 25.8 %. Sensory profiling using a general descriptive analysis revealed a significantly higher saltiness of the seawater blanched sample compared to the other treatments as well as a higher umami intensity compared to the freshwater blanched sample, which was characterized by low scores across all sensory attributes, indicating greater loss of flavour-active compounds. Lower scores for saltiness were reflected in lower content of sodium and potassium. Addition of seawater-blanched kelp, even at fairly low concentrations (0.5 and 1 %), to a commercial food product significantly affected the taste. The product with kelp was characterized by a higher saltiness, indicating the potential of kelp to replace salt in food products.

Abstracts

ALGAE4IBD: Searching for IBD treatment in algal diversity

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Algae4IBD's mission is to develop commercial products for Inflammatory Bowel Disease (IBD) prevention and treatment using aquatic natural biological resources. With the emerging developments in natural product, notable success has been achieved in discovering natural products and their synthetic analogues with anti-inflammatory activity. Micro and macroalgae, found in marine and freshwater, have been identified as promising sources of bioactive compounds including small molecules and secondary metabolites with a wide range of bioactivities such as antioxidant, anti-inflammatory and cancer preventive. Those offer an enormous potential for developing commercial products with public health benefits. Consumption of algae could, therefore, provide defence against chronic inflammatory diseases such as IBD, that until date have no effective cure. This project offers nature to bedside approach, using an entire development along the value chain for a new biodiscovery therapeutic approach by developing and examining algae-based compounds for IBD patients while guaranteeing algae's biodiversity preservation. We propose innovative solutions for increasing the use of algae-based ingredients and to ensure the science-based improvement of nutritional quality and its effect on public health. The researchers, companies and hospitals involved in the different stages of the project uses the biodiversity of algae, as a source for bioactives using state-of-the-art cultivation and extraction technologies to obtain sufficient amounts of active molecules. Those extracts have already generated bioactivity hits that will result in novel algal-based, high-quality bioactive compounds at GMP grade and lower costs for dual purposes – IBD prevention and treatment in relevance to the food as well as the pharmaceutical industries.

Abstracts

Screening of compounds/extracts with neuroprotective activity from Vietnam seaweeds

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Vietnam is very diverse and rich in seaweed/macroalgae species. The major economically important seaweed groups can be used for food and feed (humans and animals), industrial materials, traditional medicine, biofertilizers as well as biofuel and new material. The present study aims to optimize the extraction conditions and evaluate the antioxidant and neuroprotective activities of 60 compounds and extracts obtained from 30 seaweed species belonging to Caulerpa, Sargassum, Gracilaria, Ulva, Kappaphycus and Eucheuma genera collecting from NinhThuan, KienGiang, Ba Ria-VungTau and KhanhHoa provinces of Vietnam from Jan to May, 2022. The survey conditions of seaweed biomass extraction include different solvents (as ethanol 70%, ethanol 96%, n-hexane, ethyl acetate and water), raw seaweed biomass: solvent ratio (as from 1:3 to 1:8), extraction time (1-10 h) and with or without the ultrasound-assisted extraction (ultrasound power 80W, 1 h, 4.7 KHz). Six bioactive seaweed-derived compounds and extracts per 60 compounds/extracts isolated were screened by evaluating of antioxidant activity using 2,2-diphenyl-1-picrylhydrazyl radical scavenging (DPPH) assay (with IC50 ~ 5 mg/mL for extracts and IC50 ~ 200 µM for compounds); acetylcholinesterase inhibitory property using acetylcholinesterase inhibitor screening KIT (with IC50 values < 100 µg/mL for extracts and IC50 ~ 100 µM for compounds) when compared to standard drug galantamine (IC50 value < 6 µg/mL). On the other hand, potential neuroprotective activity against amyloid beta (Aβ25-35) induced neurotoxicity in C6 cells was conducted. Overall, the outcome of the study signifies the neuroprotective effect of 6 compounds and extracts from 30 seaweed species of Vietnam.

Abstracts

Phlorotannin-loaded gold nanoparticles for innovative skin health products.

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Brown seaweed phlorotannins exhibit potent antioxidant activity, reducing UV-induced oxidative stress responsible for skin aging. Phlorotannins inhibit enzymes which break down proteins, a process responsible for wrinkle formation and dark circles. The shelf-life of phlorotannins is short, due to loss of antioxidant activity. Skin penetration of the hydrophilic phlorotannins restricts their activity to the outer skin layer (the stratum corneum). To increase efficacy of phlorotannin-based skin care products, the design of a lipophilic delivery system will allow deeper penetration into the skin. Delivery of such skin care products to the subdermal layers will ensure antioxidant activity at the site known to initiate skin aging.

Gold nanoparticles are lipophilic delivery systems that can penetrate the stratum corneum, delivering hydrophilic antioxidant molecules. Phlorotannins reduce gold chloride solutions to create gold nanoparticles, called phlorotannin-loaded gold nanoparticles. A homogenous particle size of the gold colloidal suspension is, however, not achieved, as the reaction is uncontrolled. Current protocols require long mixing time (8-48 h) but industry standard nanoparticle sizes for skin health product formulations are not achieved.

The Vortex Fluidic Device (VFD) is an advanced energy-efficient green technology that has unique and diverse applications for controlling reactions. Due to topological fluid flow-induced sheer stress, the VFD shortens reaction times required for gold nanoparticles formation. Results show that the VFD creates uniform nanoparticles at a size more suitable for sub-dermal delivery of phlorotannins. Importantly, the approach represents a green strategy for the synthesis of phlorotannin-loaded gold nanoparticles, meeting industry demand in quality and functionality.

Abstracts

Fucoidan enhances human immune cell activities and stops prostate cancer cell growth in the presence of Nivolumab.

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Fucoidans are a class of brown seaweed-derived, fucose rich sulfated polysaccharides that are known to have direct and indirect effects on cancer cells *in vitro* and *in vivo*. In this study, we investigated the effect of fucoidan extracts from *Fucus vesiculosus*, *Undaria pinnatifida* and *Macrocystis pyrifera* on ex vivo human peripheral blood mononuclear cells (PBMCs), to determine their cancer cell killing activity on a hormone resistant prostate cancer cell line, PC3 both solely, and in combination with an immune-check point inhibitor drug, Nivolumab. All fucoidan extracts activated PBMCs and increased the effects of Nivolumab. Interestingly, all fucoidan extracts had a direct cytostatic effect on PC3 cells as shown through their proliferation reduction, while the cell killing activity was not mediated by fucoidan.

Abstracts

Anti-Inflammatory, Anti-Aging and Wound Healing Potential of Polysaccharides from Seven Red Algal Species of Commercial Interest

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Wound healing is an active, complex, integrated series of cellular, physiological, and biochemical changes initiated by the stimulus of injury in a tissue. The present study was performed to investigate the potential immunomodulatory abilities of polysaccharides extracted from seven different type of seaweeds species that were characterized by ^{1}H NMR, HPLC-SEC and FTIR Spectrometry techniques. Red seaweed samples (*Hypnea pannosa, Pterocladiella caerulescen, Gracilaria corticata, Gelidiopsis variabili, Chondrus crispus, Pyropia yeozensis, Furcellaria lumbricalis)* were collected from Sri Lanka, Japan, Norway and Estonia. To determine the cytotoxicity and proliferation of polysaccharides, MTT and alamarBlue assays were used, respectively. The scratch and exclusion wound models were used on HaCaT and HDF cells to assess the cell proliferation and migration. RAW 264.7 cells were used to evaluate Nitric Oxide (NO) production and phagocytosis activities. Phagocytosis is a critical part of the immune system and was measured using natural red intake by microphages cells. Anti-inflammatory and wound healing activities were observed on RAW264.7, HDF and HaCaT cells treated with different polysaccharide fractions (obtained by cold and hot extraction). Polysaccharides from *Gracilaria corticata* at the concentration of 0.5 µg/µL, (*P<0.05*) showed the highest proliferative and migratory effects on HDF and HaCaT cells. RAW 264.7 cell proliferation and/or migration were higher for *Hypnea pannosa* (cold extracted polysaccharide, 0.5 µg/µL, 151.2 ± 13.5%) and *Gracilaria corticata* (hot extracted polysaccharide, 0.5 µg/µL, 158,4 ± 7,99%) compared to the control (100%). Scratch wound healing were remarkably enhanced in 24 and 48 h (*P<0.05*) when treated with polysaccharides from *Hypnea pannosa and Furcellaria lumbricalis* on HaCaT cells. RAW 264.7 treated with the *Hypnea pannosa* and *Gelidiopsis variabilis* showed a significantly increased NO production (*P<0.05*) within 24 h with 4.53 ± 0.14 µM and 4.59 ± 0.18 µM, respectively. Phagocytosis results also revealed that the healing process proceeded significantly faster when the cells were treated with *Gelidiopsis variabilis*, *Chondrus crispus* and *Furcellaria lumbricalis* polysaccharides. Cell proliferation and migration are significantly faster when treated with polysaccharide concentration of 0.5 µg/µL. Moreover, cold extracts of red algal polysaccharides did not cause any toxicity to RAW 264.7, HDF, or HaCaT cells within 24 h. *Hypnea pannosa* and *Gracilaria corticata* could be considered as potential healing agents. The effect comes from carrageenans, which promoted keratinocyte proliferation and fibroblast migration in this study. Polysaccharides found in red seaweeds have promising wound healing properties.

Abstracts

Antioxidant and anticancer activities of Malaysian seaweed, *Sargassum polycystum* extracts against human cancer cell lines

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Seaweeds are considered very attractive sources for the screening of biologically active compounds due to their huge biodiversity. Seaweeds have long been used in traditional Asian foods and folk medicine. The present study was conducted to determine the antioxidant and anticancer activities of different extracts from Malaysian brown seaweed, *Sargassum polycystum* against four different cancer cell lines, namely human breast MCF-7, human liver HepG2, human cervical HeLa, and human colorectal HT-29 cancer cell lines. The antioxidant activities were evaluated by Ferric Reducing Antioxidant Power (FRAP), 2,2-diphenyl-picrylhydrazyl (DPPH), and β-carotene bleaching assays. MTT assay was used for the cytotoxicity test. Hexane extract showed higher antioxidant activity in FRAP and higher percentage inhibition of β-carotene bleaching activity. Ethanol extract showed higher antioxidant activity in DPPH and had the highest total phenolic content and flavonoid content with the value of 66.8 ± 2.15 mg GAE/g sample and 42.47 ± 0.24 mg CE/g sample respectively. The proliferation, apoptosis, and cell cycle arrest were determined. The results showed that chloroform extracts were antiproliferative against HepG2 and HT-29 at 50% inhibition concentration (IC50) with values of 151 µg/ml and 408 µg/ml respectively. The alginate water extract was antiproliferative against HeLa with IC50 of 360 µg/ml and acetone extract was antiproliferative against MCF-7 with IC50 of 386 µg/ml. The selected extracts induced cell cycle arrest time-dependently in HepG2 cells at the sub-G1 (apoptosis) phase of the cell cycle. These findings suggested that *S. polycystum* extract has the potential to be used as an antioxidant and anticancer agent.

Abstracts

Antioxidant potential of purified phlorotannins from Australian fucoids for the food industry.

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While seaweeds have traditionally been important in East-Asian diets for centuries, seaweed consumption remains under-exploited in Western countries, despite demonstrated antioxidant activity and health benefits. Natural antioxidants are valuable to the food industry because they are non-toxic food preservatives that can prevent various diseases. High antioxidant activity has been reported for phlorotannins that act as eco-defensive molecules and are particularly abundant in fucoid brown algae. We hypothesised that intertidal and shallow-subtidal Australian fucoids may be rich in antioxidant phlorotannins at levels suitable for exploitation, due to high solar- and UV-radiation exposure. We compared the radical-scavenging activity of purified phlorotannins extracts from four temperate Australian fucoids compared to that of five commercially exploited French fucoids, and positive antioxidant controls (vitamin C, BHA (Butylated hydroxyanizole) and BHT (Butylated hydroxytoluene)), using ORAC (Oxygen Radical Absorbance Capacity), DPPH (2,2-Diphenyl-1-picrylhydrazyl) and FRAP (Ferric Reducing Antioxidant Power) assays. Results showed high radical-scavenging activity of phlorotannins for all seaweeds studied, but with significant differences between species, and some differences among assays. All three tests highlighted the high activity of phlorotannins from the Australian fucoid *Cystophora torulosa*, showing no difference with BHA, but significantly better activity than vitamin C and BHT. The ORAC assay also suggested interesting activity for *Hormosira banksii* and *Phyllospora comosa* extracts. Finally, the Australian fucoids extracts had comparable or higher activity relative to exploited French fucoids. This study reveals interesting antioxidant properties in novel Australian species, warranting further investigation into the commercial applications and sustainability of these seaweed polyphenols for food and food products.

Temporal variation in distribution, abundance, and reproduction of Australian *hijiki* analogues in southwest Victoria

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Southern Australia possesses the highest regional diversity of seaweeds globally, with very high endemism, but there has been limited investigation of Australian macroalgae, particularly fucoid species, for aquaculture production of food and other commercial products. *Sargassum fusiforme,* known as *hijiki* in Japanese, is a sargassaceous fucoid that has been harvested for food and medicine for thousands of years in Asia, with significant health and therapeutic benefits and a highly valued flavour and texture profile. However, concerns about high arsenic levels in hijiki limit importation into Australia and Europe due to strict safe-food regulations and standards. Two Australian hijiki analogues have favourable taste, palaltability and nutritional profiles and preliminary data suggest arsenic levels are significantly lower than in hijiki, creating opportunities for domestic and export markets. However, little is known of the basic reproductive biology and ecology of these promising species. This study aims to investigate the temporal variation in distribution, abundance, growth, and reproduction of two Australian sargassaceous fucoids that show promise as low-arsenic alternatives to hijiki at two sites in southwestern Victoria. The results will be discussed considering the contribution of this research to future investigation into 1) optimal spawning conditions for aquaculture production of these species, 2) nutritional profiling for commercial applications as food and as alternatives to hijiki, 3) conservation and management strategies of macroalgal biodiversity hotspots in temperate reef ecosystems, such as the Great Southern Reef initiative.

Abstracts

Morphological and genetic analysis of *Eisenia arborea* along the Pacific Coast of Baja California, Mexico

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Eisenia arborea is the kelp with the longest latitudinal distribution on the East-Pacific of North America (Vancouver, Canada to Baja California Sur, Mexico). Its broad distribution must be sustained by a high phenotypic plasticity and adaptation phenomena. However, few studies have linked the plasticity of some morphological traits (e.g. stipe length and hollowing, blade surface roughness) with oceanographic conditions (such hydrodynamics and nutrients availability), and even the genetic basis of its phylogeographic distribution still remained unknown. In this study, we collected *E. arborea* adult sporophytes from six different sites along 800 km of the peninsula of Baja California. We measured their morphological characteristics (number of blades, maximum blade length, blade width, stipe length and perimeter) in order to find correlations with oceanographic conditions from each site (temperature, salinity, and current velocity). The genetic differentiation among populations was also analyzed. Significant differences in morphological variables were observed among all sites. The PCA analysis explains 40% of the variance by the oceanographic variables. The dispersion graph clearly differentiates the sampled sites. Twelve microsatellites reported for *Eisena cava* were tested, but no significant genetic structure was observed. However, DNA sequencing based on ITS, *rbcL*, atp8 and trnW1 assigned all specimens to *E. arborea*. ITS and atp8 showed the highest number of haplotypes (5), while trnW1 showed 3, and *rbcL* 2 haplotypes. This study found moderate intraspecific genetic diversity and a shallow phylogeographic structure. The main structure showed 3 main clades along the Pacific Coast of Baja California.

Abstracts

Genetic tools to inform and future-proof global upscaling efforts to conserve, restore and farm kelp

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The UN Decade of Ocean Science for Sustainable Development and the Decade of Restoration have strengthened global efforts to farm, restore and 'future-proof' declining kelp forests. These efforts require informed selection of genetic units (sources of kelp seedstock) to avoid negative effects on populations and optimise restoration and future-proofing success - but these data are lacking for most kelp species and regions globally. To close this gap, we built an interactive web tool from a global database of seaweed genetic structure mined from > 90 datasets, covering 35 species of high conservation and farming value. Seaweed genetic turnover was modelled as a function of geography, ocean currents and local environmental conditions using generalised dissimilarity models (GDMs) from individual datasets. We then mapped each species' genetic structure across their respective global range using the best GDM models. These maps allow rapid and explicit delineation of kelp populations that are genetically similar, unique or vulnerable to environmental change. To test this tool in action, we used it to identify "suitable" versus "non-suitable" source populations to restore the kelp *Ecklonia radiata* on West Australia's coast, and experimentally compared restoration success using the Green Gravel technique, which enables large-scale planting of kelp genotypes onto natural reefs. This global tool will enable managers, restoration practitioners and aquaculture proponents to interactively identify populations of high conservation value, and identify suitable areas to source kelp populations for restoration, farming and future-proof scenarios to increase resilience to climate change.

Abstracts

Experimental assessment of environmental versus genetic influences on *Macrocystis* morphology

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The giant kelp, *Macrocystis pyrifera,* exists as distinct morphological variants—or "ecomorphs"—yet the mechanism for this variation is uncertain, and whether these morphological features are genetically fixed or malleable under different environmental conditions is unclear. The two most common ecomorphs, *"pyrifera"* and *"integrifolia,"* exhibit almost no geographic overlap across their ranges in North and South America; however, in laboratory settings they are able to interbreed. Our study directly compared the growth and morphology at all life stages of the two *Macrocystis* ecomorphs in a common garden experiment. We experimentally tested the influence of local environment on giant kelp morphology by rearing lab-cultured embryonic sporophytes from spores released by *"pyrifera"* and *"integrifolia"* sporophylls collected from multiple individuals at Stillwater Cove, California. The spores were cultured in three treatments: pyrifera only, integrifolia only, and mixed (50:50 pyrifera:integrifolia spores). We outplanted the resultant embryonic sporophytes to concrete blocks at 7.5-9 m depth in the ocean and monitored their development over five months. Results showed distinct differences in morphology between the pyrifera and integrifolia treatments at multiple stages of development including reproductive adults, indicating that the morphological differences between the two ecomorphs are genetically determined rather than environmentally induced. Primary stipe length and number of branches can be used as diagnostic traits for distinguishing the ecomorphs prior to the stage when adult sporophyte morphology can be definitively characterized. Additionally, no morphological hybrids were observed in the mixed treatment, and individuals resembled either integrifolia-like or pyrifera-like forms.

Abstracts

DNA markers for cross-breeding and improving cultivation of the editable brown alga, *Cladosiphon okamuranus*

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Okinawa mozuku, *Cladosiphon okamuranus*, is one of many edible brown algae, yielding 22 Kton annually and contributing ¥5 billion to the Japanese economy. The life cycle of *C. okamuranus* is complicated, since the alga has self-cloning life cycles in both haploid (N, male and female) and diploid(2N) conditions, but only diploid "seeds"(germlings) become edible sporophytes. Because haploid and diploid germlings are morphologically indistinguishable, haploid germlings are often mistakenly combined with diploid germlings for cultivation, which results in less efficient harvesting of mozuku. Sexual identification of haploid germlings is essential to develop better diploid strains by crossbreeding. With this aim, we performed RNA-seq analysis of haploid germlings of *C. okamuranus*. Using its decoded diploid genome and transcriptomic information, we identified 269 genes that are expressed specifically in male or female haploids. BLAST analysis with *Ectocarpus siliculosus* gene models revealed that nine of 269 genes were putative sex determination-related genes of *C. okamuranus.* A unique set of polymerase chain reaction primers for these nine genes was designed, and DNA amplification using primers enabled us to distinguish male and female haploid and diploid germlings. This tool will enable mozuku farmers to select diploid germlings free of haploid germlings. Using this DNA marker technique, the amount of mozuku cultivated in Okinawa is expected to increase

Abstracts

Conditions influencing the abundance of ‘green tide’ macroalgae in a tropical intertidal zone of Southern Philippines

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Three green (Chlorophyta) macroalgal species (*Ulva reticulata, U. intestinalis, Chaetomorpha crassa*) have become a nuisance in many coastal zones and beaches in the Philippines. We studied the temporal variation in dry weight biomass of these three species on November, February, May, and August in three intertidal sites representing a highly urbanized and industrialized area, a densely populated suburban area, and a highly agriculturised area. We also sampled select physico-chemical conditions (water temperature, dissolved oxygen, water motion, insolation, pH, dissolved NO_3-N and PO_4-P, salinity, rainfall and total suspended solids) that were regressed with variations in biomass of the three species. Except *U. intestinalis* which was seen only in May and August in all sites, the other two species were observed throughout the sampling period and peaked in February. *Ulva reticulata* was consistently in the top 8 most abundant species in the Dalipuga site. It occupied top 13-18 in other sites, except during the rainy month of August when it became top 2 in the Northwestern Bay and top 9 in the Southern Bay coinciding with decreased species richness at these two sites. Constrained multivariate redundancy analysis revealed significant relationship between biomass peaks and high levels of PO_4-P and water motion, and moderate light intensity. In conclusion, *U. reticulata* and *C. crassa* are opportunistic species in that they bloom under ideal conditions of nutrient (PO4-P), water motion and insolation, and may dominate the macroalgal community under stressed conditions (reduced salinity and high turbidity).

Species identification for a crustose calcifying red algal community that induces Acropora surculosa recruitment

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The health and recovery of coral reefs following disturbances is inherent to the success of invertebrate larvae recruitment to reef substrate. Members of crustose calcifying red algae (CCRA) are a preferred substrate for scleractinian coral larval recruitment, yet species-specific settlement preferences are still largely unknown. Studies of coral larval recruitment preference to CCRA species often use morphological observations, resulting in species misidentification. Accurate identification of CCRA species is essential for coral reef restoration and management to detect favorable CCRA species for coral larvae settlement. DNA sequencing is becoming a favoured methodology to aid in CCRA species identification and to assess CCRA community composition. Molecular tools have revealed that this algal group is more species-rich than previously thought based on morphological assessments. The objective of this study was to (1) utilize DNA sequencing to investigate the taxonomic richness of a CCRA community on coral recruitment tiles while simultaneously using photo analysis and (2) evaluate species-specific recruitment preference of Acropora surculosa larvae to the CCRA tile community. Twenty-seven distinct CCRA species of the orders Corallinales and Peyssonneliales comprised this study's 12 coral recruitment tiles, resulting in a species-rich community assemblage. One species, Lithophylloideae sp. 1, was significantly preferred by A. surculosa larval for recruitment. Detailed knowledge of species-specific interactions and community assemblage is necessary for coral reef management due to increased disturbances to coral reefs, resulting in a steady decline in coral cover.

Abstracts

Safeguarding the carrageenophyte cultivation industry: a case study in Malaysia

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Kappaphycus and Eucheuma account for almost 90% of the world's carrageenan production and the industry is projected to reach US$ 1 billion in value by 2024. The carrageenophyte cultivation industry is one of the key economic sectors in Malaysia, and the third largest producer of carrageenophytes after Indonesia and the Philippines. The demand for carrageenan is expected to increase with time but in recent years, production has declined, signaling an urgent need for a concerted effort to provide solutions to safeguard this industry. To date, our localised genetic profiling, in synergy with the efforts of the GlobalSeaweedSTAR consortium, indicate that virtually all the cultivated strains of *Kappaphycus alvarezii* and *K. striatus* in the world belong to very few haplotypes. This affects the overall productivity over time, given that genetic diversity is vital for maintaining resilience of the seaweeds and the ecosystems in which they occur. Limited genetic variation in the farmed seaweeds may increase disease outbreaks, in particular ice-ice and epiphyte infestation, which, coupled with climate change, increases the vulnerability of the industry. To work towards practical solutions, efforts include documenting genetic diversity of indigenous wild populations, developing genetically diverse strains as potentially new cultivars that are resilient to climate change, particularly temperature increase, and pests and diseases, and implementing a conservation strategy through long-term capacity building. Omics analyses are underway to determine potential causes of ice-ice disease, along with genetic profiling of the associated epiphytes. This research will help safeguard the Malaysian carrageenophyte industry and has potential application elsewhere.

Abstracts

Consequences of calcification for coralline algal ecology and evolution

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Calcification is a defining characteristic of coralline red algae that has likely impacted their ecology and the trajectory of their evolution for millions of years. Yet, the exact influence of calcification on ecological and evolutionary processes is fraught with assumptions, especially as adaptive landscapes may have shifted over time. For example, coralline have repeatedly overcome the biomechanical challenge of a calcified thallus and the resulting limitation on vertical growth by evolving flexible joints (genicula), giving rise to species with upright articulated fronds. However, some erect coralline thalli have weakened or restricted calcification, resembling fleshy seaweeds, and still persist alongside their calcified relatives. Moreover, recent work has identified crust species that evolved from articulated ancestors, representing evolutionary reversals that raise questions about the adaptive significance of upright growth entirely. Ecologically, calcified thalli are generally resistant to herbivory, but the exact mechanism of protection remains unclear. Serial decalcification of several coralline species had no significant effect on urchin or isopod grazing rates: fully calcified thalli were eaten as much as fully decalcified thalli. In only one coralline-grazer interaction did we document an increase in herbivory after decalcification, suggesting that protection provided by calcification is not generalizable and may be interaction-specific. Moreover, we found that the caloric value of a standardized volume (or "mouthful") of coralline algae is similar to – and sometimes greater than – that of kelp, undermining past claims of caloric differences. As coralline research expands, we should revisit our basic assumptions about the past and present impact of calcification on coralline ecology and evolution.

Abstracts

Algae Foundation's algal-based education and workforce development; a global initiative developing bioeconomy professionals

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Algae Foundation is an American non-profit organization dedicated to all forms of algal-based education, workforce development and training. The Algae Foundation's mission is to promote the "Power of Algae" to transform human society and the environment upon which it depends. Currently in its seventh year, The Algae Foundation (AF) has served over 140,000 students and trainees from 100 countries.

The ATEC initiatives are intended to develop algal-based bioeconomy workforce development, education and training programs including: 1. Community college and university based curricula in Algal Cultivation and Biotechnology; 2. A student competition - AlgaePrize; 3. Algae Cultivation Extension Short-courses (ACES); 4. Algae Academy and CULTIVATE, K-12 STEM education programs; 5. Algae Massive Open Online Courses; and 6. Microcredentialing Digital Badging Programs. The AlgaePrize, launched 1/13/2022, is a U.S. Department of Energy sponsored competition to develop new algal technologies supporting gigaton scale algal cultivation.

ATEC 2016-2022 accomplishments include: Algae Academy ~ 110,000 students in 49 states, 1 territory and 3 countries; Adoption of ATEC curricula by 25 community colleges and universities with nearly 2000 students involved taking algal-based courses, laboratories, and degree programs awarding its first degrees in 2018; Algae MOOCs #1 (Introduction to Algae) and #2 (Algae Biotechnology) have attracted > 28,000 students with a 98 % approval rating; ACES has been taken by more than 2250 students from 100 countries: and the ATEC microcredentialing digital badging program earned a national endorsement by the Algae Biomass Organization in July 2019.

Abstracts

The principals and application of direct seeding for seaweed cultivation

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A seaweed farmer has two distinctly different methods of planting seaweed at their disposal. The first method is by using a hatchery, in which seaweed attach themselves on substrates under controlled environments. The second method is called direct-seeding, in which seaweeds are out planted directly in the ocean, rather than requiring a 6 week incubation period for their attachment. The seaweeds are kept in place on the ropes in the ocean, before they attach themselves, through a combination of specialized ropes and binders. The intricate balance between the catchment and attachment of the seaweed on the ropes, in combination with the chemical properties of the different binders makes this an exciting frontier of applied seaweed research.

Hortimare believes that direct seeding has a bright future, with great potential for further optimization. We therefore intensively collaborate with farmers from all over the world to validate and optimize their direct seeding practices. A machine that is both small, modular, and manually operatable was used with positive effect to standardize a variety of tests and reduce variance in long line yields. The fact that several farmers used exactly the same seeding method allowed us to compare results, and create a standard in the market to build from in the years to come. This presentation will delve deeper into the process of direct seeding, its challenges, opportunities, and potential pitfalls.

There are two distinctly different methods for outplanting seaweed at the disposal of a farmer. The typical method is by using a hatchery, in which seaweed attach themselves on substrates under controlled environments. The novel method is called direct-seeding, in which unattached seedlings are seeded directly onto ropes and out planted in the ocean, rather than requiring an incubation period (weeks-to- months) for their attachment. Direct-seeding uses a synergy of specialized ropes and binders to keep the unattached seedlings in contact with the cultivation ropes, while they attach themselves. This novel method may greatly reduce the cost of seeding, as well as encouraging seeding standardisation and opportunities for future automation. Scientifically, this is an exciting frontier of applied research, as there is an intricate balance between the catchment and attachment of the seaweed on the ropes, in combination with the chemical properties of the different binders.

Hortimare collaborates intensively with farmers from all over the world and using different species (mainly kelp) to validate and optimize direct seeding practices. We will present a direct-seeding machine that is both small, modular, and manually operatable. Several of our collaborating farms are now using this machine, allowing the direct comparison of results and a standard in the market to build from in the years to come. This presentation will delve deeper into the process of direct seeding, its challenges, opportunities, and potential pitfalls.

Abstracts

Macroalgae cultivation materials: Assessing chemistry and microstructure for a reliable, cost-effective seeding solution

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The seaweed industry is a huge global industry worth over $11 billion per year, however cultivation technologies are still in relatively nascent stages of development in the UK and other parts of Western Europe. The successful production, deployment and growth of seeded materials is a principal concern in determining operational costs and subsequent yield. The search for efficient, reliable and durable cultivation materials (e.g., ropes, twines) contributes to the economic and environmental success of seaweed aquaculture. Seaweed producers can avoid high nursery costs and uncertain production yields, while promoting circularity of cultivation materials and sustainable practices.

We assessed the performance of different cultivation material microstructures on the growth and early development of gametophytes and spores of brown macroalga (*Saccharina latissima* and *Alaria esculenta*) from the West coast of Scotland, UK.

For this, different microstructures were seeded either with (i) gametophytes, (ii) spores, or (iii) gametophytes in combination with hydrocolloid binders. The trials combined several controlled flume-based studies seeking to understand material microstructures, flow (50cm s^{-1}), and binder interactions. Materials with high porosity and complex microstructures presented a range of cultivation benefits for gametophytes. Spore seeding showed promising results by an increase in the number of active growing loci per mm^2, especially on microstructures with pore sizes of

> 15µm. Binder trials demonstrated improved 'seed' retention in high-energy environments typical of many cultivation sites.

Overall, results suggest that the microstructure of seeding materials plays a crucial role in the growth and early development of cultivated macroalgae.

Abstracts

A practical application for urchin conspecific alarm cues as feeding deterrent

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The capacity of urchins to overgraze algal beds is well documented. Currently, the most effective way to restore seaweed ecosystems is to reduce urchin populations by removal. However, these can be expensive and success can be limited. Here we evaluate an alternative method of reducing grazing pressure by inducing predator-avoidance behaviors in the urchin *Heliocidaris crassispina*. We used fresh *H. crassispina* extracts embedded in food-grade agar discs as a feeding deterrent in field conditions. We also investigated the physical properties of agar as a medium to deliver the urchin extracts in a controlled manner. We tested two concentrations (10% and 20%) against a control (0%, plain agar) and observed urchin behavior using a time-lapse camera for 5 days. The results suggests that higher concentrations are effective over lower concentrations as there was a progressive decrease in the number of urchins in-frame at 20% but not at 0% and 10%, over the observation period. Moreover, we also suggest strategies for applying this method in field conditions.

Abstracts

RNA-Seq analysis reveals a downregulation of immune associated genes in *Delisea pulchra* following pathogen exposure

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Host-microbe interactions are essential for the health of marine organisms but can be highly sensitive to changing environmental conditions. As such, increasing global seawater temperatures can promote host stress and lead to the emergence of opportunistic pathogens, leading to an increase in the occurrence of diseases in marine organisms. Disease outbreaks affecting macroalgae are of particular concern due to their critical role as habitat forming organisms. However, there is a limited understanding of the cellular response strategies used by macroalgae to respond to opportunistic pathogens while subjected to thermal stress. In this study, we used mRNA-Seq analysis to investigate the response of the model macroalga *Delisea pulchra* (Rhodophyta), after exposure to a known opportunistic pathogen (*Aquimarina* sp. AD1) relative to a closely related benign strain (*Aquimarina* sp. AD10). Using *de novo* assembly methods, 27,586 unique transcripts belonging to *D. pulchra* were identified that were mostly affiliated with stress response and signal transduction processes. However, following pathogen exposure a clear downregulation of genes encoding for protein metabolism, stress response, energy generation and photosynthesis functions was observed, relative to the benign strain. This transcriptional repression of genes encoding for core cellular processes is predicted to ultimately interfere with the macroalgal pathogen response, leading to infection, tissue damage and bleaching symptoms. Overall, this study highlights the potential pathogen response mechanisms of macroalgae and contributes to an improved understanding of host-pathogen interactions in a changing marine environment.

Abstracts

Process water of whiteleg shrimp *Litopenaeus vannamei* can be used to fertilize *macroalga Caulerpa* lentillifera

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Sea grapes (*Caulerpa lentillifera*) are edible macroalgae valued for their nutritional benefits and special texture. This alga is of high demand in Asia and cultivated among others in Vietnam. Land-based culture of tropical shrimp *Litopenaeus vannamei* in recirculation aquaculture systems (RASs) is popular in Germany and a simultaneous culture with other species, like sea grapes, could lead to a more efficient resource use and provision of tropical sea vegetables to European customers. Therefore, we explore the potential to use *L. vannamei* process water for fertilization of *C. lentillifera*. The process water was diluted to reach five nitrate treatments (artificial seawater, low, medium, high, pure process water, with ~2, 48, 144, 720, 14400 µmol L^{-1}, respectively) and different NO_3^-/ PO_4^{3-} ratios (28, 5) through additional PO_4^{3-} feralizations, following literature suggestions. Sea grapes at nitrate treatments medium and high, independently of the PO_4^{3-} fertilization, showed significantly higher relative growth rates than other nitrate treatments. As well as a larger share of economically valuable frond thallus parts, compared to stolons. Additionally, photosynthesis, amino acid (AA) pattern and total hydrolysable AA (THAA) amount were influenced by nitrate treatments. A two-way ANOVA revealed a significant effect of nitrate treatment and the interaction with PO_4^{3-} fertilization ($p < 0.05$) on THAA, with PO_4^{3-} fertilized medium and all high treatments showing the highest THAAs. The preliminary results revealed that sea grape fertilization with *L. vannamei* process water could increase the algae's quality and growth, initiating a discussion for a simultaneous culture of both species in intensive RASs.

Abstracts

The ups and downs of water quality within a commercial recirculating IMTA Abalone/Ulva system: Effects of increased recirculation on critical parameters

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In South Africa, several commercially operated land-based abalone farms employ integrated aquaculture (IMTA) technology to grow the local abalone, Haliotis midae, together with the seaweed Ulva lacinulata. On the studied farm, ammonia removal by Ulva enables routine continuous 50% water recirculation. Ulva is also harvested and used as supplementary feed. The farm is divided into platforms, each containing four independent modular clusters, which consist of a single paddle raceway containing ca.1 ton Ulva (volume 300,000l) linked with ca. 10, 000 -15,000 kg of abalone within 42 tanks (volume of each tank 8,000l).

A series of experiments examined system water quality parameters at standard farm operation (50% recirculation), increased recirculation (75% recirculation), and the effects of short-term 100% recirculation, the latter designed to test the potential to prevent Harmful Algal Bloom (HAB) intake during external environmental events. At 50% recirculation, TAN removal across the Ulva biofilters ranged from 65-85% and pH ranged from 8.1 (daytime) to 7.5 (night). Data show a strong positive linear relationship between TAN removal and TAN load to the biofilter, with %TAN removal higher during the day. No significant differences in temperature, pH, TAN or FAN were observed between the 50% and 75% recirculation clusters. At 100% recirculation, temperature was consistently 1°C higher, and pH was around 1 unit lower. TAN and FAN increased rapidly at 100% recirculation, with TAN values ranging from 0.3-0.8 mg l-1 compared with values less than 0.1mg l-1 at 50%. The commensurate rapid and considerable decrease in pH however meant that the FAN increase was not as high as it would be at ambient seawater pH. Oxygen levels were not considered problematic at any stage in the experiments. It is clear from the data that this system could feasibly run for extended periods at 75% recirculation, with relatively little effect on water quality compared with 50% recirculation.

Abstracts

Effects of multiple drivers of change on seaweed from Aotearoa New Zealand

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Multiple climate change drivers are manifesting in our oceans simultaneously. Ocean acidification reduces the calcification rates of calcareous taxa and alters dissolved inorganic carbon uptake in seaweeds, while ocean warming and increasing frequencies, durations and intensities of marine heatwaves cause physiological stress to many marine species. Predicting the impacts of marine heatwaves is complex, with differing durations and intensities of thermal anomalies possibly eliciting responses that vary by species, population or individual. Ocean acidification can be classified as a multiple driver, with changes in HCO_3^-, H^+, CO_2 and possibly CO_3^{2-} all having physiological ramifications for various seaweed species. Here I give an overview of insights gained over the last four years of manipulation experiments with seaweeds in the North Island of Aotearoa New Zealand, focusing on the identification of generalities in their physiological responses to multiple drivers of change.

Abstracts

Environmental change at the fringe: seasonally distinct responses of kelps within high latitude *Macrocystis* beds

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Marine climate change in high latitude oceans will overlay onto the distinct seasonality of these environments. Our knowledge of how such environmental variability and change will interact to affect kelp productivity in these regions is limited. This lack of data is particularly evident for the macroalgal communities associated with the globally abundant giant kelp *Macrocystis pyrifera,* which has been studied extensively at lower latitudes but rarely considered at the polar edges of its range. To assess the current production potential of giant kelp forests at their high latitude fringe, we conducted a multi-year field study of the growth and turnover dynamics of *M. pyrifera* and co-occurring understory kelps *Hedophyllum nigripes* and *Neoagarum fimbriatum* in Sitka Sound, Alaska. We then grew these kelps in the lab within seasonally relevant scenarios of light and nutrient availability under current vs. end-of-century projections for temperature and pCO_2. We found that *Macrocystis* beds in southeast Alaska produce an estimated ~150 g C · m^{-2} · yr^{-1} and turnover an estimated 2.1 times per year, on average substantially lower rates than have been observed at lower latitudes. However, carbon production of high latitude giant kelp was unaffected by end-of-century temperature and pCO_2 conditions, regardless of season. In contrast, the more poleward-occurring understory kelps exhibited reduced growth and nutritional content under elevated future summer temperatures. Incorporating seasonally-specific global change scenarios for macroalgal populations across the breadth of their range will be critical to understanding future impacts to temporal and spatial variation in kelp species' production.

Abstracts

Physiological responses of the kelp *Eisenia arborea* in artificial deep refugia in Baja California, Mexico

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Understanding the biological plasticity of kelps at their distributional boundaries is critical for predicting their responses to climate change responses. Shallow-water thermal stress can result in widespread mortality, especially at lower latitudes where the incidence of thermal anomalies can be extreme. The *in situ* management strategy of transplanting sporophytes to deeper waters when substrate is not naturally colonized can protect against shallow thermal stress by taking advantage of deeper cooler refugia, allowing for population survival and recolonization when optimum conditions return. However, artificial deep refugia also provides challenges, such as light limitation for photosynthesis. This study tested an artificial deep refugia for *Eisenia (=Ecklonia) arborea,* near its southern latitudinal limit (Baja California Sur, Mexico). Eisenia arborea is the stipitate kelp distributed furthest south in the northeast Pacific where populations are often exposed to higher temperatures than the rest of the range. Intertidal *E. arborea* sporophytes were transplanted below the thermocline to 7 and 15 m depth (50% to 90% of surface irradiance), and their short-term physiological responses were examined (photobiology, oxidative stress, nutrient content and nitrate uptake kinetics). *Eisenia arborea* exhibited photoacclimatory adjustments to reduced light availability, with increased photosynthetic efficiency and reduced non-photochemical quenching. Nitrate uptake rates decreased with depth, yet were maintained at lower nitrate availability (< 2 μM) sustaining optimum tissue nitrogen content. No sign of oxidative damage was detected. Our results suggest potential for the use of artificial deep refugia in the framework of kelps conservation and restoration strategies under climate change.

Abstracts

Intraspecific variation in thermal tolerance, and restoring Australia’s disappearing giant kelp (*Macrocystis pyrifera*) forests

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Kelp forests are the foundation of the Great Southern Reef, Australia’s continent-wide temperate reef system that supports high levels of biodiversity, endemism, and economic value. Unfortunately, in Australia and elsewhere, kelp forests are declining due to climate change, overgrazing from herbivores, and coastal development and pollution. Globally, some of the most dramatic declines have occurred in Tasmania, Australia, where 95% of giant kelp (*Macrocystis pyrifera*) surface canopies have disappeared since the 1950’s. Habitat restoration is one potential tool for kelp forest conservation, but critically, any restoration intervention must first address the ongoing challenge of climate change that continues to drive giant kelp loss.

Here we outline the key drivers of giant kelp forest loss in Australia – increasing water temperatures and reductions in coastal nutrients – and present a novel restoration approach using more warm-tolerant giant kelp genotypes. We summarise the results of experimental work that identified high intraspecific variation in thermal tolerance of *Macrocystis* in Tasmania, and provide an update on (ongoing) restoration field trials using those genotypes that exhibited increased warm-tolerance. We also briefly introduce components of the broader project looking at the physiology, genetics, and breeding of *Macrocystis* in Tasmania, and of kelp restoration decision-making. Ultimately, we aim to provide a foundation for future-proofing efforts to maintain and restore kelp forest resilience in a global ocean-warming hotspot, and to provide risk-management to habitat restoration in a rapidly changing climate.

Abstracts

A knowledge synthesis of nutritional quality and climate performance for Saccharina latissima

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The climate effects of farmed seaweeds is a hotly contested topic with numerous knowledge gaps regarding their nutritional and health benefits. This study reviews the climate and nutrition performance of farmed sugar kelp, in comparison with reference foods, e.g. herbs, vegetables and meat products. Cradle to farm-gate climate impacts were recalculated using harmonized methodologies and life cycle inventory data from 6 LCAs published between 2012-2020. Data on the nutritional content of unprocessed and whole dried sugar kelp was collected in a systematic literature review in Sep 2021, then aggregated into nutritional density scores based on the Nutrient Rich Food Index (NRF11.3, 21.3).

Results show that sugar kelp has a high nutrient density and a low climate impact relative to many other common foods such as meats, vegetables and herbs. However, the estimations neither account for nutrient bioavailability nor for effects from processing such as drying, blanching or up-concentration of proteins. Further studies are warranted to determine the effect of processing on nutrient density and carbon emissions. Though the climate impact is low compared to other foods, typical portions of sugar kelp in western diets remain very small and it is not yet clear what type of food it can be compared to, so one must be careful suggesting climate benefits can be achieved by substituting other common foods. This review contributes to consolidating the potential of seaweed as a nutritious and low impact food source in future diets.

Abstracts

Thermal performance of the habitat forming kelp Ecklonia radiata under ambient and elevated CO2 levels

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Identifying the responses of kelps to ocean warming and marine heatwaves requires an understanding of the point at which temperatures become stressful for a given population. Moreover, as warming is not occurring in isolation, understanding the influence of co-occurring future-ocean drivers such as elevated CO_2 on thermal performance is needed to accurately project how populations will respond in a future ocean. In temperate Australia, *Ecklonia radiata* is the most widespread and abundant habitat forming kelp. *E. radiata* forms extensive forests and persists in seawater temperatures ranging from ~ 7 – 26 °C. *E. radiata* is susceptible to warming and marine heatwaves at the warm edge of its distribution, yet little is known about the thermal vulnerability of cool edge populations, and whether thermal performance is influenced by elevated CO_2. To address this gap, we measured performance (growth, net photosynthesis) of *E. radiata* to eight temperatures (6- 29 °C) under both ambient and elevated CO_2 (RCP 8.5 emissions scenario). Responses were used to construct thermal performance curves (TPCs) to identify thermal optimum and critical upper limits for growth and photosynthesis. Thermal optima were found to be considerably lower than those previously reported from warm edge populations and highlight the potential adaptation to local temperature regimes. TPCs were used to model annual performance under climate change and marine heatwave scenarios using historical SST data and future warming projections. Results suggest susceptibility to marine heatwaves is greatest in late summer and early autumn and this susceptibility will be exacerbated in a future ocean.

Ecology of kelp gametophytes: grazing in a warming ocean

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Kelp forests are biodiverse habitats that provide vast ecosystem goods and services but are in decline due to a range of anthropogenic stressors. Ocean warming is driving the transition of kelp forests to alternative states like urchin barrens and algal turfs, resulting in dramatic declines in biodiversity. To mitigate such profound ecosystem changes, an understanding of the ecology of kelp across all life cycle stages necessary. Kelps have a heteromorphic alternation of generations, and while there is growing understanding of the mechanisms driving change in the macroscopic sporophyte stage, the ecology of the microscopic gametophyte stage remains a knowledge gap. Here we give an overview of some of the most pressing questions concerning gametophytes, and present some of our research starting to fill these gaps. Of particular importance are biotic interactions of gametophytes with grazers, which may be a mechanism limiting reversal from barren and turf states to kelp forests. We show that several micro-grazers can negatively impact gametophyte persistence but also facilitate their reproduction. Warming appears to have little impact on herbivore grazing, but does hamper gametophyte recovery from grazing and their ability to recruit into sporophytes. These findings show the complexity of ecological interactions of kelp microscopic stages and beg further research on the ecological functioning of kelp gametophytes under climate change.

Abstracts

Limits and thresholds to seaweed farming, a theoretical approach to carrying capacity for seaweed farming

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In recent years, Europe has demonstrated growing interest in seaweed farming. Yet, an open question is whether upscaling will lead to negative impacts that can occur with too much growth and too intense farming. Today in a growing industry, ecological, social, and economic sustainability all need to be considered. With limited space, scarce resources and conflicting industries, policy makers and local governments need to make choices on how to sustainably develop their coasts and industries, while keeping the environment safe and having social acceptance and economic stability. We propose to use the interdisciplinary concept of *carrying capacity* to define the limits of acceptable change and to support the sustainable and inclusive growth of the seaweed sector, looking at ecological, social and economic aspects.

To determine the carrying capacity of a specific activity, for example farming in a certain area, theoretical limits need to be elaborated, supported by quantifiable indicators and parameters. Then data will be collected which describe the current status of an ecosystem, production and societal opinion of this activity. Besides models to map the quantitative data, also ambiguities and changes in opinions and discussions of trade-offs can find their place. Based on this data, implications for the maximum possible size (extent of upscaling) of a farm can be derived which still keeps the ecosystem and society safe and sustainable.

This presentation will show the development of a conceptual framework that is needed to define the notion of the seaweed carrying capacity and will specify data requirements for its application.

Effects of slow-release fertilizer and blue light on *Undaria pinnatifida* growth in the cultivated field

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The fishery production of *Undaria pinnatifida* commonly consumed seaweed in Japan is declining. Possible causes of the decline are rising water temperature and lowering nutrient concentration. Several studies indicated that additional nutrients and blue light emission had positive effects on the growth of *U. pinnatifida* in the lab. However, such experiments have rarely been conducted in the field. Therefore, this study aims to examine the *in-situ* effects of slow-release fertilizer and underwater blue LED light. We cultivated young sporophytes from Nov 2021 to March 2022 in the inner part of Shizugawa Bay, northeastern coast of Japan. Additional nutrients were slow-release fertilizer, and blue LED light was emitted from 6:00 pm to 6:00 am. Three experimental treatments were additional 100 g slow-release fertilizer group (F), 100 g fertilizer with blue light emission group (F+L), and control group (C) with no additional treatment. The average relative growth rates (RGR) of the blade length obtained by punch-hole method in C, F and F+L were 1.5, 1.8 and 1.4 cm/day, respectively. The average RGR of sporophyll length in C, F and F+L were 0.9, 0.9 and 1.2 cm/day, respectively. It is concluded that the growth of blades was accelerated by slow-release fertilizer under the condition with no blue light. On the other hand, sporophyll growth was assisted by the fertilizer with blue light emission and resulted higher yield of larger sporophyll production. We supposed that additional nutrients and blue light emission eased intraspecific competition and ensured all individuals to grow well.

Abstracts

Moving may be a good thing: how water motion influences cultivation of *Saccharina latissima*

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Water motion is a fundamental component of the ocean and important for the wellbeing of seaweeds in the environment as it influences factors such as nutrients and light availability. However, during cultivation in hatcheries, seaweeds are often grown with just air stones as a form of water movement. Essentially, too little motion may result in mass-transfer limitation, potentially slowing the growth rate of the seaweed in the hatchery phase. To ensure security of a reliable large-scale supply of seaweed; at a cost which is competitive with alternative food sources, time in the hatchery phase should ideally be optimised. The influence of oscillatory versus mesocosms with air stones on the growth and density of the microscopic stages of the sugar kelp *Saccharina latissima*, were investigated. A significantly higher sporophyte density was found when the seaweed was exposed to oscillatory motion in comparison to the mesocosms (F= 28.67, $P < 0.001$); however, when there was little external force acting on the blades, as in the mesocosm, a significant increase in blade length was observed (F = 42.26, $P < 0.001$). Providing water motion therefore did increase the density, but not growth rate. However, whether, traditional methods of cultivating seaweeds in the hatchery means there is a trade off in blade strength and therefore more susceptible to breakage when grown out in the field in more energetic environments is unknown and requires further investigation.

Abstracts

Intraspecific variation in seasonal performance of *Ecklonia radiata*

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Intraspecific variation is critical in driving adaptation to changing environmental conditions and is driven by local adaptation, genetic diversity and phenotypic plasticity. While differences in mean performance measures are commonly assessed when comparing species and populations, the extent and drivers of intraspecific variation within natural populations remain considerably less well known. Further, the presence of high-performing individuals within a population may be an indicator of a population's potential to adapt to a changing climate. In this study we assessed intraspecific variation in performance of two natural *Ecklonia radiata* populations in Western Australia across annual cycles of

environmental conditions. We measured elongation rates and survival of over 400 individuals across two locations over a two-year time period that varied in temperature by ~7 °C. By monitoring tagged individuals, we aimed to evaluate the magnitude of variation within populations through seasons and identify the extent to which high- and low-performing individual are present. Our findings showed that mean elongation rates and variation were correlated, with an increase in both during colder months. While we found differences between individuals with some individuals consistently ranking as high- or low-performing, there was no clear relationship between higher elongation rates and survival. This study highlights that performance can be used to assess a population's current state, however, a combination of performance measures is needed to evaluate future performance in a changing climate.

Abstracts

Soft sediment macroalgal communities of Otago Harbour, New Zealand

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Macroalgae play a critical role in the functioning of many coastal ecosystems, from rocky reefs to soft sediment environments. In the past, research focus has been placed predominantly on rocky reef systems with soft sediment habitats being relatively poorly understood. Soft sediment habitats can host extensive and diverse algal meadows that may serve as sites of significant ecological importance. This study examined the community dynamics of soft sediment macroalgal habitats in Otago Harbour, New Zealand. *Adamsiella chauvinii*, an endemic red alga, forms extensive meadows in soft sediment environments. The meadows play a key role in nutrient cycling, sediment stabilisation, and are known to support elevated species diversity including species of fisheries importance. Seasonal and spatial surveys were undertaken to assess biomass, community composition and species diversity within *A. chauvinii* beds in Otago Harbour, along with key predictors of algal growth (light, temperature and nutrient concentrations). Results show strong seasonal variation with biomass being the highest in autumn, along with a strong spatial variation with outer harbour recording higher biomass and species diversity. Environmental drivers of these patterns will be discussed. An unexpected finding across multiple sites was the presence of the invasive macroalgae *Undaria pinnatifida* which utilises *A. chauvinii* blades as a substrate for holdfast attachment and growth. This study provides detailed data about community composition, diversity, and distribution patterns across time and space, key information for driving effective ecosystem-based coastal management.

Abstracts

Analysis of pelagic sargassum biomass harvested in Jamaica

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Pelagic *Sargassum* have been known for centuries in the Sargasso Sea of the North Atlantic Ocean. In 2011, a new area concentrating high biomass of these brown algae started developing in the Tropical Atlantic Ocean. Since then, massive and recurrent *Sargassum* influxes have been reported in the Caribbean and West Africa. These events negatively impact coastal ecosystems and nearshore marine life, and affect public health, coastal living, tourism, fisheries, and maritime transport. Despite recent advances in the forecasting of sargassum events and elucidation of the seaweed composition, many knowledge gaps remained, including morphotype abundance during *Sargassum* events, drift of the seaweeds prior to stranding, and influence of sample processing on biomass composition. Analysis of samples harvested on the coasts of Jamaica in summer 2020 showed that *Sargassum fluitans* III was the most abundant morphotype. No clear difference in the geographical origin of the sargassum mats was observed. The majority of sargassum backtracked from both north and south of Jamaica experienced ambient temperatures of around 27 °C and salinity in the range of 34-36 psu before stranding. Cheap (sun) compared to expensive (freeze) drying techniques influenced biomass biochemical composition. Sun-drying increased the proportion of phenolic compounds, but had a deleterious impact on fucoxanthin and monosaccharide content, except for mannitol. Effects on fucose containing sulfated polysaccharides content depended on their extraction method. Limited variation was observed in ash, protein, and fatty acid content. Such information is important for the storage and transport of the biomass in the context of its valorisation.

Abstracts

Effects of climate change and species facilitation on the restoration of shallow marine forests

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Forest-forming macroalgae can be particularly sensitive to environmental conditions, especially during early life stages. As a result, climate change could lead to a worldwide loss of marine forests and the lack of evidence of natural recovery highlights the need for imminent restoration actions. Therefore, it is essential to consider the role played by abiotic and biotic factors when assessing the outcome of future restoration actions. However, not much is known about the effects of ocean warming and acidification on *Cystoseira s.l.* species. These drivers can also affect its associated understory species, mainly crustose coralline algae, likely playing a role in the recruitment of later successional species. We studied the interactive effects of ocean warming, acidification and species facilitation (i.e. presence of crustose coralline algae) on recruits of *Cystoseira compressa* to assess the potential of restoring this species under climate change. Recruits were maintained at 24, 28 and 32°C, at ambient (pH_T = 8.07) and low pH (pH_T = 7.8) and in the presence or not of the crustose coralline algae *Neogoniolithon brassica-florida*. We demonstrate that ocean warming, acidification and the presence of the coralline algae negatively affect the recruitment of *C. compressa*. The density of recruits was lower under high temperatures and low pH, whereas the size was negatively affected by the temperature increase but positively affected by the low pH. While new techniques recently opened the door to the restoration of marine forests, our results show that climate change has to be considered to achieve long-term restoration success and ensure population sustainability.

Abstracts

Recovery and bioactivity of volatile halogenated natural products from post-harvest processing of *Asparagopsis taxiformis*

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Asparagopsis taxiformis is renowned for its production of antimethanogenic bromoform, or tribromomethane. However, the genus produces hundreds of other halogenated compounds including halo- alcohols, ketones, acids and other alkanes, most of which were identified in the 1970s and early 80s. Many of these compounds are volatiles and/or present at low concentrations, meaning that their bioactivities remain largely uncharacterised. Recently, while evaluating different drying protocols for *Asparagopsis* as a feed additive, we inadvertently recovered a range of volatile halogenated compounds that we had not detected in any format of dried biomass. Here, we report the method for recovering and concentrating the volatile natural products of *Asparagopsis* in the condensed water from low-moderate heat drying. Bioassay guided fractionation was done with four levels of comparison, starting with three environmental samples. Overall, the three condensates were tested against four pathogenic bacteria, exhibiting a bactericidal effect similar to the antibiotic gentamicin. Fractionation and further partitioning of the compounds allowed us to evaluate different concentrations and combinations of compounds against *Salmonella enterica* subsp. *typhimurium* and *Acinetobacter baumannii* which are responsible for the majority of food-borne pathogen-related deaths and increasing incidences of nosocomial infections, respectively. These results identified that most of the activity was due to ~10 different compounds, none of which were bromoform. This paper highlights a process whereby multiple bioactive compounds can in turn be targeted for multiple applications by applying a biorefinery approach to utilising the 'waste' of the seaweed drying processes.

Abstracts

The kinetics of ultrasound-assisted alginate extraction from *Ecklonia maxima* with and without cellulase addition

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Alginate is an important biomolecule found in brown seaweeds and is commercially extracted using conventional chemical extraction pathways. Ultrasound-assisted extraction (UAE) and enzyme-assisted extraction (EAE) are two potential alternative extraction methods that can be employed for alginate extraction from brown seaweeds, at operating conditions that are milder than those employed during conventional chemical extraction methods. However, alginate extraction rates that can be achieved using UAE and EAE are poorly described, yet will play an important role in commercialisation of these extraction technologies. The aim of the study was therefore to determine the optimum conditions for extraction of alginate from *Ecklonia maxima* using enzymatic extraction in the presence of ultrasonication, and to model extraction kinetics. Firstly, a 2^3 factorial experimental design was employed at constant sonication rate, with pH (8 and 10), temperature (50 and 60 °C), and enzyme-to-substrate ratio (E:S 0 and 1 %) as the independent variables. Secondly, extraction kinetics of alginate were investigated at different extraction conditions, through fitting of the Peleg and Power models. Optimum extraction for alginate was achieved at pH 10, 60 °C, E:S = 0 % within the first 60 min of extraction. The addition of enzyme improved solubilised dry matter content, despite its less clear impact on the alginate yield. Both the Peleg's (R^2 = 0.893 – 0.997) and Power function (R^2 = 0.861 – 0.987) models provided good fit to the experimental data and can suitably be used to describe extraction kinetics of alginate during combined ultrasound-enzymatic assisted extraction.

Investigating the Functionality of the Ulvan Utilising Plasmid in *Alteromonas* sp. 76-1

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Uncontrolled macroalgal blooms known as green or golden tides are increasingly occurring around the world, due to eutrophication of the marine ecosystem. These blooms result in the generation of large quantities of biomass that are currently underutilised. The predominant cause of green tides is the genus ***Ulva*** which contains ulvan, a sulphated polysaccharide with unique monomers such as rhamnose, glucuronic acid, iduronic acid and xylose. Oligomers and monomers of ulvan have several applications in the biomedical, biofuel, cosmetic and fine chemical industry. These applications often necessitate the breakdown of the polysaccharide to oligosaccharides or monomers and can be achieved through enzymatic saccharification. Owing to the complexity of ulvan, the synergistic action of several enzymes such as ulvan lyases, unsaturated glucuronyl hydrolases, rhamnosidases, xylosidases and sulfatases are essential for its complete saccharification. Koch et al (2019), reported the presence of a plasmid with several ulvan metabolising CAZYmes in *Alteromonas sp.* 76-1 isolated from the Patagonian continental shelf. This plasmid has genes for the complete set of enzymes required to breakdown ulvan to monomers. In this study, we investigate the functionality and potential of the ulvan metabolising genes that are present on this plasmid towards ulvan saccharification. This work can contribute to the development of sustainable enzymatic technologies for the utilisation of green seaweed biomass generated due to algal blooms.

Reference: Koch H.et al (2019) Frontiers Microbiol.10:504

Optimization of pre-treatments, frozen storage and thawing to increase the shelf life of sugar kelp.

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Seaweed has one large untapped potential in Europe. Norway has a long coastline with a well-established aquaculture sector, and good prerequisites for large-scale kelp cultivation. One of the main challenges for industrial players is to maintain the quality after harvest, as large quantities of biomass are collected within a limited period of time. Effective preservation methods that minimize the loss of valuable compounds and maintain quality is crucial to the profitability of this new European industry. This will provide increased value creation in the coastal industry and support sustainable development of European bioeconomy. In the pilot project ISBIT (NRC272111), freezing and intermediate storages using Refrigerated SeaWater (RSW) technology were evaluated with respect to product quality, energy use and the potential for industrial use. Based on the results from this pilot project, ISBIT2.0 (NRC285154) defined the optimal conditions for pre-treatments, frozen storage and subsequent thawing of sugar kelp and examined concrete solutions for the design of a mobile processing unit in commercial sugar kelp production. The knowledge gained in the project will be used further by regional actors in fisheries, aquaculture, R&D and producers. The projects were led by Møreforsking AS and conducted in collaboration with SINTEF Ocean, SINTEF Industry, NTNU and industry partners such as FrigoCare, Tafjord Kraftvarme AS, Seaweed Energy Solutions AS, Ocean Forest AS, Tango Seaweed AS, RContainer AS and Teknotherm Marine AS.

Abstracts

Phenolic compounds content and antioxidant activity of wild macroalgae *Ulva* sp. *vs* cultivated *Ulva rigida*

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Macroalgae are relatively easy to cultivate/produce at industrial scale making them relevant natural resources of bioactive compounds. Wild macroalgae are more exposed to stress factors and are expected to be richer in bioactive compounds than the cultivated ones. The aim of this work was to compare the phenolic content and the antioxidant activity between wild algae (*Ulva* sp.) collected off the Portuguese coast and cultivated algae (*Ulva rigida*). Differences between fresh and freeze-dried/air-dried samples were also assessed. Higher antioxidant activity is generally observed in wild seaweed collected in summer and spring. Wild samples of both seasons were also analysed for comparison. The samples studied were LWU-Su (Lyophilized Wild *Ulva* sp. from Summer), FWU-Sp (Fresh Wild *Ulva* sp. from Spring), WUL-Sp (Lyophilized Wild *Ulva* sp. from Spring), FCU (Fresh Cultivated *Ulva Rigida*), LCU (Lyophilized Cultivated *Ulva rigida*), DCU (Dried Cultivated *Ulva rigida*).

The extraction of bioactive compounds was performed using an ethanol:water mixture (75:25), and the extracts obtained were screened for total phenolic content (TPC) and the antioxidant activity (Ferric Reducing Antioxidant Power - FRAP) (Table 1).

Higher phenolic contents and antioxidant activities were obtained for cultivated samples when compared to the wild ones. Regarding fresh *vs.* dried samples, fresh samples presented both higher content in phenolic compounds and antioxidant activities. It was also observed that freeze-drying was the drying process that best preserved the bioactive compounds. Regarding the samples collected in spring *vs.* samples collected in summer, no statistically significant differences were observed.

Table 1. Total phenolic compounds (TPC) and antioxidant activity (FRAP) of Ulva sp. extracts.

	TPC (mg GAE/g algae)	FRAP (µmol AAE/g algae)
FWU- Sp	0,29 ± 0,09 a	0,43 ± 0,26 a
LWU- Sp	0,16 ± 0,04 b	0,25 ± 0,06 b
LWU- Su	0,13 ± 0,03 a	0,30 ± 0,06 a
DCU	0,09 ± 0,03 bc	0,18 ± 0,04 bc
FCU	0,32 ± 0,06 cd	0,85 ± 0,12 b
LCU	0,22 ± 0,03 d	0,29 ± 0,11 c

Different low case letters in the same row indicate significant statistical differences (p<0.05).

GAE, gallic acid equivalents; EAA – ascorbic acid equivalents.

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Chemical structures of phlorotannins from six brown seaweed species and their antibacterial and antioxidant activities

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Phlorotannins are highly hydroxylated polymeric metabolites produced by brown seaweeds, and known for their wide array of bioactivities, which makes them interesting for many fields of applications. It is strongly suspected that the strength of their bioactivities is directly related to their chemical structure. The present study aims to characterize the phlorotannin's chemical structure of six abundant brown macroalgae, known to produce different types of phlorotannins: two species were collected in the tropical Atlantic Ocean (*Sargassum natans, Sargassum fluitans*), while the others were exploited by French companies (*Sargassum muticum, Laminaria digitata*, *Laminaria hyperborea* and *Ascophyllum nodosum*), sampled either on the coasts of Brittany or Normandy (France). Phlorotannins were extracted and extensively purified to obtain phlorotannin-rich fractions. The chemical structure was then elucidated through 2-Dimensions Nuclear Magnetic Resonance spectroscopy (2D-NMR) and Mass-Spectroscopy (MS). In parallel, the fractions were tested for their antioxidant activity as well as their antibacterial activity against several bacterial strains of interest for human health and cosmetics. Results of activities are linked with the structure of phlorotannins and highlight the interest to propose phlorotannins as promising metabolites for human well-being.

Abstracts

Evaluation of the isolation and purification of milk-clotting enzymes from marine macroalga *Gracilaria edulis*

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Cheese-making involves milk coagulation as a crucial step. Rennet, a substance derived from the abomasum of a young calf stomach, has been used traditionally as milk-clotting enzyme in the cheese industry. However, the supply of rennet is limited and unable to meet the growing demands in cheese production. Moreover, there is an issue for vegetarians to consume cheese products made from rennet as it is derived from an animal-based source. A number of rennet substitutes have been explored, including pure chymosin produced by molecular technology, animal pepsin, plant and microbial proteases. However, these milk coagulants still have various drawbacks, including limited availability, low yields, high bitterness, and consumer concerns about animal ethics and genetically modified organism (GMO). Therefore, the continual search for rennet alternatives is necessary. Seaweeds are a potential source of milk clotting enzymes that have not been well explored. This study evaluated a milk-clotting enzyme from seven species of seaweed including different post-harvest processing, extraction and purification procedures. Protein extracts of all seven species of seaweeds exhibited some caseinolytic activity, but the extract of unprocessed (whole, dried) samples had higher protein yields and stronger caseinolytic activity. The extract from one species, *Gracilaria edulis*, demonstrated the ability to clot milk. The evaluation of the purification method for G. edulis extract revealed an optimum single step of 50% saturation and ammonium sulphate precipitation with dialysis as the desalting method.

Abstracts

Integrating metabolomics and DNA to uncover diversity patterns in species of *Ecklonia* from southern Africa

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Kelp forests are among the most productive ecosystems in our oceans, supporting biodiverse and commercially important species. The only major kelp forest in Sub-Saharan Africa occurs in southern Africa, where these habitats are formed largely by species of *Laminaria* and *Ecklonia*. Two species of *Ecklonia* are widespread, with *E. maxima* dominant along cool temperate coastlines to the west, and *E. radiata* along warm temperate regions to the east, including nearby offshore reefs. More recently, an "*Ecklonia* contact zone" has formed at the southern tip of Africa, following a recent eastward shift in the range of *E. maxima*. The aim of the present study was to elucidate the chemical and genetic diversity of *E. maxima* and *E. radiata* in southern Africa and to determine whether these two species hybridize. This was achieved by using a combined metabolomic and DNA approach applied to populations of *Ecklonia* collected from throughout its known distribution range in southern Africa spanning roughly 3500 km of coastline. We used untargeted metabolomics by LC-MS/MS and *cox*1, with an additional gene applied to the potential hybrids, to estimate the overall chemical and genetic diversity respectively. Our data largely resolved distinct biogeographic groups within each species and supported a third distinct group intermediate between *E. maxima* and *E. radiata*. The combined metabolomic and DNA approach was powerful in elucidating patterns of diversity and structure in *Ecklonia* along this dynamic coastline. We believe that such information can help guide MPA planning and management of these species in the future.

Sargassum diversity on the Brazilian coast: a new interpretation based on molecular data

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Sargassum C. Agardh, 1820 (Fucales, Phaeophyceae) is one of the most diverse genera of marine macroalgae, with 351 benthic and two pelagic species, the latter form the Sargasso Sea. Most species of *Sargassum* are described only on the basis of morphological characters, some of which have been shown to vary in the same individual and/or population. The plastic morphology in species of the genus causes problems such as doubtful identifications, overestimation of species and, consequently, doubts about their occurrence. Benthic species of *Sargassum* are common along the Brazilian coast and are a structuring component of marine communities, but the number of species is still uncertain. Currently, 14 species have been cited, by different authors, for the genus on the coast of Brazil. In this work we investigated the diversity of *Sargassum* species on the Brazilian coast using molecular markers and morphological analysis. Samples (benthic and holopelagic) were collected along the coast, identified based on morphological criteria and four different molecular markers (ITS2, *cox*2, *cox*3, *cox*3-*atp6*) were sequenced. Phylogenetic analyses and species delimitation methods were used. Nine morphospecies were identified, however, molecular data agreed with only two genetically distinct species occurring on the Brazilian coast. The implications of future taxonomic changes will be discussed.

Elucidation of the brown algal gamete evolution with a new timeframe and organelle data

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Brown algae (Phaeophyceae) are one of the six eukaryotic lineages that achieved complex multicellularity and shows morphological variability of gametes (isogamy, anisogamy and oogamy). In contrast to the previous theoretical assumption that asserted correlation between anisogamy and cellular complexity and instability of isogamy (the PBS theory), there exist multiple lineages of isogamous species in the brown algae. However, the factors that prevented gametes from diversifying into large eggs and small sperms have remained unclear. Based on the robust phylogeny constructed with plastome data, we estimated the timing of lineage diversification and transitions in gamete types within the brown algae. We showed that simple multicellular brown ancestor achieved complex multicellularity with cell-to-cell communication and tissue differentiation ca. 900-800 Mya, after which ancestral isogamy has persisted extraordinarily long with parthenogenetic ability, which is consistent with the recent modeling paper. We also presented reversions of oogamy to isogamy occurred during or after the Late Paleozoic ice age (360-260 Mya) and two mass extinctions (Permian–Triassic and Triassic–Jurassic), implying that the parthenogenetic post-glacial colonization and recovery after extinctions induced the transitions back to the original isogamous states. With comparing the extent of incomplete lineage sorting in organelle genomes between isogamous and non-isogamous lineages, we present an ‘isogamous ancestral polymorphism’ model to elucidate the possible advantages of parthenogenetic isogamous species during the re-colonization process. The main findings of the study will shed light on future studies on the relationship between the gamete dimorphism and various strategies of life cycle.

Abstracts

Organelle phylogenomics of the genus *Vaucheria* reveals the evolutionary history and unique mitochondrial genome structure

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The genus *Vaucheria* is a grass-like yellow-green algal group (Xanthophyceae, Ochrophyta) inhabiting various aquatic environments such as freshwater streams, lakes, salt marshes, and seashores. Interestingly, this genus is the unique group having diverse sexual reproduction modes, from hermaphroditic, monoecious, to dioecious, while other Xanthophyceae only have the asexual mode. Although their physiological and sexual diversification, just a few systematics studies had been conducted using several phylogenetic-marker genes, and there is no genomic application. In this study, we collected 20 *Vaucheria* species (or strains), and sequenced organelle genomes (i.e., plastids and mitochondria) with an asexual ancestor *Asterosiphon dichotomus* to explore the phylogenetic relationships underlying the evolution of this fascinating algal group. We also performed comparative genome analyses to investigate structural variation and genetic repertoires. As a result, we constructed complete plastid and mitochondrial genomes of all species and inferred a more reliable evolutionary history correlating with habitat adaptation and sexual reproduction mode. We also found a unique mitochondrial genome structure by identifying large inverted-repeat regions that had never been reported in the Ochrophyta lineage. This study will help provide a genomic view for understanding the evolutionary biology of the *Vaucheria* and furthermore Xanthophyceae.

Abstracts

Seaweed biobanking at the Culture Collection of Algae and Protozoa: preserving diversity for the future

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The Culture Collection of Algae and Protozoa (CCAP) is a very diverse biological resource centre with nearly 3000 strains of microalgae, macroalgae, cyanobacteria and protozoa. Of those, 900 are macroalgae, covering a broad diversity with around 100 genera and 200 species.

CCAP has a long history of cryopreservation research and many of the strains in the collection have been cryopreserved. Cryopreservation can offer a great solution to establish seaweed biobanks and enable the preservation of genetic diversity for future research, industrialisation, and as a way of *ex-situ* conservation of diversity that might be able to regenerate species that are lost to their natural habitat.

The brown kelp *Saccharina latissima* has been identified as a key biological resource due to its relevance environmentally and as a key species for European aquaculture, with ongoing breeding programs being established to improve its cultivation. To preserve these resources, a biobank was created in collaboration with partners of the H2020 GENIALG consortium. Fertile *S. latissima* sporophytes were sampled across the species' European biogeographic range, with female and male gametophytes isolated and cryopreserved according to methods established by Visch et al. (2019). These strains and metadata are publically available, and represent an extensive, genetically characterised, biological resource encompassing the European range of *S. latissima*.

Culture collections, such as CCAP have huge ecological and economic importance, for the seaweed aquaculture which relies upon genetic diversity for developing breeding programs but also for the conservation and management of wild populations that might be vulnerable to climate change.

Health benefits of consuming seaweed – a myth or clinically proven?

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The potential health benefits associated with seaweed consumption is a hotly debated topic that often arises when advocating the inclusion of seaweed in the Western diet. Its perception as a "healthy" food commodity is likely due to the abundance of dietary fibers, essential elements, and *in vitro* bioactive phenolic compounds. However, clinical evidence is needed to corroborate promising *in vitro* findings. This narrative review analysed randomized-controlled interventional trials (RCTs) from the last 22 years that tested whole seaweed. We aimed at critically assessing the methodology and Cochrane risk-of-bias as well as existing links between seaweed consumption and health endpoints.

Of the 26 RCTs collected, the most studied primary outcomes were blood glucose, blood lipids, and urinary iodine reflecting a focus on metabolic disorders and thyroid function. For the first two, the percentage of RCTs reporting significant reductions after the intervention compared to control diets was 40 and 18%, respectively, whereas 57% reported an increase in urinary iodine. A preliminary overall risk-of-bias judgment revealed that around 83% of all RCTs were at high-risk of bias, which altogether limits the possibility to draw firm conclusions. Regarding methodology, a total of 22 RCTs used dried seaweed with large variations in pre-treatment and drying methods, which impairs potential comparisons between RCTs testing the same species. Also, 15 RCTs opted for encapsulated seaweed, although most did not report potential flavour differences/similarities versus the placebo.

Overall, more well-designed RCTs are warranted to generate stronger clinical evidence on the role that seaweed can play in disease prevention.

Abstracts

Seaweed for food and beverage innovations– what do the 'makers' want?

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Australia has a clean, green food and beverage image, with many micro- to small- businesses seeking novel ingredients to differentiate their products. These businesses ('makers') represent individuals from across the value chain, including input suppliers, manufacturers, restaurants, and consultants. Seaweed is emerging as a novel ingredient in the Australian food and beverage market, and we employed a cross-sectional descriptive study to evaluate its potential. A survey targeting small-scale food and beverage enterprises across Australia was disseminated to explore what the 'makers' themselves think about introducing seaweed into their businesses. Overall, participants (n=44) had positive perceptions of seaweed and its potential in the industry. More than ¾ of participants agreed that seaweed is unique and provides opportunities for product and market innovation. Most were aware of the nutritional benefits of seaweed. 'Health' was reported as a primary reason for wanting to use seaweed, followed by altruistic motivations around sustainability and the environment. Key barriers to using seaweed included availability and access, knowledge and information about seaweed uses, and understanding of costs involved. More than half of respondents also expressed concerns about taste. These findings highlight implications for the emerging industry to support the commercial use and application of seaweed. The health aspects, and their value to both makers and consumers, have a role in driving demand. Further, more effort is needed to support the capability of makers to use seaweed via sharing of knowledge and research, as well as clear strategies to achieve sustainable broad-scale production and stable supply of seaweed.

Abstracts

Contribution of seaweed to health and nutrition in Samoa: a dietary modelling simulation study

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Seaweeds have diverse nutrient compositions with great potential to contribute to healthy diets. This is especially so in Samoa, where there is increasing prevalence of food and nutrition insecurity and diet-related non-communicable diseases. Local edible seaweeds are highly accessible and rich in macro and micro-nutrients, yet little is known about their contribution to diets in Samoa. This study used a simulation approach, modelling different scenarios to determine the potential contribution of seaweed towards recommended nutrient reference values in Samoan diets. Enumerator-administered 24-hour dietary recall interviews were conducted using a purpose built digital dietary assessment tool (PAC24) based on the gold standard automated multiple-pass method. A total of 234 participants were interviewed from 10 villages across two islands (Savai'i and Upolu) in Samoa. Nutrient intake assessment was undertaken using FoodWorks 8 Pro, Xyris (2009) Ltd. and compared to recommendations. Overall diets were low in thiamin, riboflavin, iron (in women), zinc (in men), and high in sodium. Dietary simulation was applied to individuals' diets to optimise nutrient intake with the addition of various seaweed scenarios. Two seaweeds, *Caulerpa* (limu fuafua) and *Halymenia* (limu a'au), were simulated in varying amounts. Quantitative biochemical analysis of samples of both seaweeds provided representative nutritional composition data. The addition of seaweeds improved total intake of key nutrients, including iron, calcium, and fibre. This simulation study identifies entry points within the value and food supply chain, highlighting the potential that indigenous seaweeds in supporting healthy and sustainable diets in Samoa.

Exploring the development of Australian seaweed ingredients for food and beverage products

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Australian edible seaweeds can make a positive contribution to local food systems as a sustainable and healthy ingredient; however, they are currently under-utilised in the food and beverage market. Understanding the perceptions of the "makers" is needed as the next step towards transforming and reinvigorating local food systems to utilise native seaweeds. This qualitative study, set on the Sunshine Coast, Australia, aimed to explore the potential for new local products using seaweeds as novel ingredients. Three focus group discussions and four semi-structured interviews were conducted with local enterprises to explore motivations, barriers, and enablers to using seaweed. In addition, some participants took part in a hands-on activity, trialling purpose-designed seaweed ingredient packs (various *Sarconema* and *Ulva* preparations). Discussions were audiotaped, transcribed verbatim, and thematic analysis was undertaken. Key themes were framed within the three pillars of sustainability: economic, environment, and social. Economically, there was a desire to meet consumer needs, market differentiation, and increased competitiveness. Access to a reliable local supply of seaweed was emphasised as a necessary input and a key environmental driver for product development. Social sustainability was emphasised as collaboration with the university, and the creation of support networks within the sector to build knowledge and skills. The concept of "local" is fundamental in this context. As such, supporting local production and supply of native Australian seaweeds is crucial. While these findings demonstrate a keen interest from businesses to utilise seaweed ingredients, local supply is needed to enable sustainable development and innovation.

Abstracts

Seaweeds for novel and healthy food products: Sea sausages as a case study

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Algae are a great source of nutrients and bioactive compounds essential for a balanced diet, providing several health benefits, and demonstrating the potential to be applied in functional/ fortified foods. Additionally, their consumption has emerged as a sustainable food alternative, especially as a replacement for other resources that may become scarce in the near future. However, its strong taste often leads to the rejection for direct consumption. Thus, the introduction of seaweeds as an ingredient becomes a necessity. New foods incorporating seaweeds need to be designed to guarantee nutritional quality, while also improving the organoleptic properties. This work aimed to develop and characterize an innovative reduced sodium sea sausage, combining *Trachurus picturatus* (an undervalued specie and so enhancing the valorisation and efficient use of marine resources) and *Palmaria palmata*. The development of a low-salt product is a key aspect, given the emerging concern associated with increasing cardiovascular pathologies worldwide. Results showed that sea sausage is a source of protein (10,1 g/100g WW) and phosphorus (129,4 mg/100gWW), and low in sodium (according to Regulation (CE) No. 1924/2006). Natural ingredients in *Palmaria palmata* are potassium and magnesium, elements with qualities that make it a substitute for sodium in food. Results also showed that the iodine, which plays an important role in the thyroid gland function, content was high (33,9 µg/100g WW) crucial in combating its widespread deficiency. Besides the nutritional potential, the sea sausage also showed an overall sensorial potential (overall acceptance of 75.5 % among 81 tasters).

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Building a seaweed industry in Northern Norway, seasonality study and development of high value fractions

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Polar Algae is a startup company initiated in 2016. Our goal is to sustainably harvest wild growing *Ascophyllum nodosum* in Northern Norway and utilize the biomass for extraction of valuable components, with a specific focus on fucoidans.

There has been no industrial harvesting of *Ascophyllum* in this area. There was an initiative in 1987 where this unique biomass was intensively mapped in the whole of Finnmark. Since then there has been no initiative to harvest and use seaweeds from the arctic Finnmark. Before Polar Algae started its journey.

Through intensive research, mapping and analysis Polar Algae is in the first phase of testing mechanical harvesting in Finnmark.

Two important aspects of Polar Algae's business development have been biomass mapping and seasonality studies of various seaweeds from the arctic region. This extensive and unique analysis has been done in close collaboration with the French company Algaia.

This presentation will include the seasonality studies performed over a period of three years which have been performed on the following six polar circle growing species:

Alaria esculenta, Saccorhiza dermatodea, Ascophyllum nodosum, Laminaria digitata, Fucus spiralis, Fucus serratus. A comparison with different EU sourcing of the same species has been developed and revealed the impact of unique environmental condition on their chemical composition. A brief overview of biomass mapping will be then presented, from satellite imagery to ground proofing. To complete, targeted bioactivities of valuables fractions will be highlighted to demonstrated the potential of the seaweed industry in this polar circle region.

Abstracts

Hanging gardens - do floating kelp farm communities resemble natural kelp forests?

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The interest in seaweed cultivation is increasing globally, which requires knowledge of the potential effect of seaweed production on the marine environment, both negative and positive. We therefore wanted to study the fauna communities found in a kelp farm and compare these with what is found in natural kelp forests with the aim of finding out if a kelp farm ecosystem resembles that of natural kelp forests. The field work was conducted in north-western Norway, just before the kelp was harvested in the spring. Fauna traps were deployed and kelp plants scraped in the kelp farm (both in the sugar kelp, *Saccharina latissima*, and the winged kelp, *Alaria esculenta,* part), in natural sugar kelp, winged kelp and tangle kelp (*Laminaria hyperborea*) forests and in the water masses. The potential effect of the duration of the growth period of the farmed sugar kelp on the associated community was also analysed. The study shows that a kelp farm has lower taxa richness and fewer individuals than natural kelp forests, but indicates that the farm still has an ecological function as a habitat. However, the communities in the farm are more similar to the natural kelp forest surrounding the farm than with the natural kelp forest of similar species. The result from this study contributes with important knowledge of kelp farms ecological role in the marine environment, which is important both for today's management and for the planned growth of the industry.

Mechanistic simulations of *Laminaria hyperborea* in a dynamic landscape of light, temperature, and winter storms

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Laminaria hyperborea is a forest-forming kelp species in the North Atlantic that provides physical structure for diverse, productive ecosystems, with populations strongly affected by light availability, temperature, and storm-related disturbance. We constructed a stage-based, two-season model of *L. hyperborea* along the coast of the United Kingdom and Ireland to predict biomass across a range of depths, drawing on extensive surveys and data from the literature. Population dynamics were driven by wave exposure, historic winter storm intensity, and simulated interannual variation in temperature and depth-attenuated light intensity, with density-dependent competition for light and space. High biomass was predicted in shallow depths across the domain on suitable substrate, with populations extending deeper in the north and west. Interannual variability increased with wave exposure and decreased with mean biomass. Annual fluctuations in light and storm intensity produced opposing 3-year population oscillations persisting for up to a decade but diminishing sharply with depth. The largest environmental effects were from storms in shallow northwestern populations. Annual variation in temperature had minimal impact. Biomass was most sensitive to settlement and survival rates, with moderate sensitivity to the lamina erosion rate and form of density dependence, and negligible sensitivity to stipe and lamina growth rates. This model reproduced observed geographic patterns of *L. hyperborea* and highlights the need for a better understanding of mortality, particularly in the subcanopy, as well as recruitment and competition. While the most dramatic impacts of interannual environmental variability come from storms in the northwest of Scotland, populations recover quickly following major disturbances.

Abstracts

The impact of substituting fat with Kappaphycus alvarezii gel on the quality of chicken patties

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Kappaphycus alvarezii is one of the largest tropical red macroalgae with significant fibre, carbohydrate, and mineral content. This study investigates the effect of replacing fat with seaweed gel *Kappaphycus alvarezii* (KA) on the physicochemical, nutritional, and sensory properties of chicken patties. The chicken patties are formulated as control sample F0 (0% KA gel + 10% fat), F1 (2.5% KA gel + 7.5% fat), F2 (5% KA gel + 5% fat), and F3 (7.5% KA gel + 2.5% fat). Proximate analysis showed the moisture, ash, and dietary fibre content increased significantly ($p<0.05$). In contrast, increasing the level of KA gel as a fat replacer considerably lowered the fat content ($p<0.05$). The inclusion of KA gel had no effect on the protein content ($p>0.05$). Next, the hardness of the KA gel treated patties decreased significantly ($p<0.05$), while there was no significant difference ($p>0.05$) in other texture parameters. Moreover, the chicken patties with KA gel seaweed have a lower expressible water and cooking loss ($p<0.05$) compared to the control sample (F0). The L* values (lightness) showed a decrement ($p<0.05$) along with a* and b* values ($p<0.05$). Chicken patties with KA gel reduced water activity significantly ($p<0.05$). The sensory evaluation reveals that F1 (2.5% KA gel + 7.5% fat) has the highest acceptance by sensory panellists ($p<0.05$) compared to other formulations. In conclusion, seaweed KA gel has the potential to function as a fat substitute in the production of reduced-fat chicken patties.

Abstracts

Physical and proximate analysis of crackers fortified with red seaweed, *Kappaphycus alvarezii*

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Kappaphycus alvarezii is a red seaweed that is popularly cultivated for its phycocolloid, kappa-carrageenan production. The demand for carrageenan is increasing due to its application in the food and non-food industry as a gelling, thickening and stabilising agent. The objective of this study is to determine the effects of *K. alvarezii* powder fortification on the physical and proximate composition of savoury crackers. The six formulations of crackers incorporated with different concentration of *K. alvarezii* powder were (Control) 0%, (F1) 1%, (F2) 2.5%, (F3) 5%, (F4) 7.5%, and (F5) 10%. Physical analysis such as thickness, colour, and water activity as well as proximate analysis such as moisture, ash, fat, protein, and crude fibre content was conducted. The result showed a significant ($p<0.05$) decrease in thickness, colour and water activity with an increasing amount of *K. alvarezii* powder added. Meanwhile, the result in the proximate analysis showed a significant ($p < 0.05$) increase in ash and fibre content with an increasing amount of *K. alvarezii* powder added. Other than that, the protein, fat, and moisture content was seen to be decreasing in trend as more *K. alvarezii* powder was added. In conclusion, the fortification of *K. alvarezii* powder in crackers showed improvement in the nutrient content and physical properties of the crackers

Abstracts

Characterisation of alginates and metal content of Australian brown seaweeds for food and biomedical applications

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Alginates are used widely in foods, textiles and pharmaceuticals for their gelling properties but are currently available from Australian seaweeds for *Durvillaea potatorum* only. Variability in the alginate yield and composition is common, with implications for commercial applications. We assessed temporal and spatial variation in the characterisation of alginates from three Australian brown seaweeds, *D. potatorum, Ecklonia radiata* and *Phyllospora comosa.* Samples were collected from three regions in Victoria, Australia over autumn, winter, and spring; alginates were extracted from dried biomass and the yield, viscosity, residual cellulose and M:G ratio (β-D-mannuronic acid relative to α-L-guluronic acid residues) characterised. Because metals can bind to alginates and affect toxicity, we also analysed the concentration of copper (Cu), manganese (Mn), iron (Fe), lead (Pb), zinc (Zn) and arsenic (As). Average alginate yields varied significantly among species (47% for *D. potatorum*, 37% for *P. comosa* and 28% for *E. radiata*), and spatially and temporally. Highest yields for all species were in spring, when maximum average yields for *P. comosa* (59%) exceeded those of *D. potatorum* (37 – 55%) at all sites. Viscosity varied temporally, highest in spring. M:G ratio differed amongst species (average 1.4 for *D. potatorum* and ~1 for the other species), but also varied temporally and spatially. Residual cellulose ranged 12 – 27% and was highest in *P. comosa*. Concentrations of all metals were below the maximum tolerable level for human consumption. Results suggest *P. comosa* should be considered for alginate production with an optimal spring harvest, but site selection may be important.

Abstracts

Elevated CO2 ameliorates the negative effects of UV radiation in the red alga *Pyropia yezoensis*

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The commercially important red alga *Pyropia yezoensis* is subject, in its natural environment, to environmental stressors including high levels of both photosynthetically active radiation (PAR, 400-700 nm) and ultraviolet radiation (UVR, 280-400 nm). UVB radiation (280-315 nm) in particular is known to inhibit photosynthesis and growth in a range of algae. However, in outdoor exposure of *P. yezoensis* for 9 days and in the absence of UVR, elevated partial pressure of CO_2 (pCO_2) at levels predicted for the end of the century led to enhanced photosynthetic carbon assimilation rate (CAR) and relative growth rates (RGR). Both UVA (315-400 nm) and UVB caused significant inhibition of CAR and RGR, but the inhibition caused by UVA was considerably reduced under high pCO_2. UVB inhibition was more severe and unaffected by pCO_2. Rapid chlorophyll fluorescence curves showed that high levels of PAR alone induced photoinhibition of inter-photosystem electron transport. In the presence of UVR, photoinduced inhibition was mainly identified in the O_2-evolving complex (OEC) and PSII. Such inhibition appeared to ameliorate the function of downstream electron acceptors, protecting PSI from over-reduction. In turn, the stable PSI activity increased the efficiency of cyclic electron transport (CET) around PSI, dissipating excess energy and supplying ATP for CO_2 assimilation. When algae were grown under elevated CO_2, CET became further enhanced, which maintained OEC stability, thus markedly alleviating UVR-induced photoinhibition. Thus, coordination between PSII and PSI endows *P. yezoensis* with a highly efficient photochemical performance in response to UVR, especially under future increased CO_2 levels.

Abstracts

Carbon use and calcification strategies in a diversity of fleshy and calcifying tropical algae across irradiance gradients on reefs of Little Cayman Island

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Tropical reef macroalgae in varying light environments may be differentially utilizing CO2 versus HCO3- for photosynthesis. We hypothesized that macroalgae in low-light environments utilize CO2 due to energetic costs of taking up HCO3-. Further, we examined calcification strategies across irradiance gradients. Fleshy and calcified macroalgal species were collected (~200 individuals; 3 Phyla) from a shallow high-irradiance barrier reef (~1,500 mmol photons m-2 s-1; ~1 m), 2 mid-depth intermediate-irradiance reefs (~600 mmol photons m-2 s-1; ~17 m), 2 deeper wall reefs (~400 mmol photons m-2 s-1; ~25 m), and low-irradiance crevices (~15 mmol photons m-2 s-1; >15 m). The 13dC of organic and inorganic tissue were analysed. The 15δN, total N and C were also determined, as well as water column nutrients and irradiance. The 13dC of organic tissue ranged from -11.8 to -25.5 with an average of -19.1 ± 3.2, indicating that all species likely utilized HCO3-. Rhodophytes had the most enriched organic 13dC signatures (-16.5), while chlorophytes and ochrophytes were similarly lighter (-20.6 and -20.9, respectively). Irradiance was a strong predictor of organic 13dC (13dC = 3.6 x 10-3 irradiance - 21.5; R2 = 0.91). Inorganic 13dC of calcifiers was genus-specific with the chlorophytes ranging between 0.5 to 3.5, ochrophytes 2.9 to 5.2, and rhodophytes 1.7 to 3.4, except for *Jania* and *Amphiroa* that had negative signatures between -2.8 to -5.1. These data lead us to suggest that tropical macroalgae primarily utilize HCO3- for photosynthesis, with some constraints from irradiance, but taxonomic differences likely drive physiological mechanisms for calcification.

Abstracts

Seaweed farming offers an avenue toward greater food security and healthier diets in Malaysia

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Malaysia used to be the third largest carrageenan seaweed producer in the world after Indonesia and the Philippines in 2010 when the government has recognised seaweed as an important aquaculture industry in ensuring food security, reducing pressure from capture fisheries, generating foreign exchange income, providing employment, extending alternative livelihoods, and creating opportunities for business and commercial investment. However, between 2012 to 2020, seaweed production in East Malaysia decreased by 45% and all carrageenan processors has shut down their factories. There is no import and export data of dried seaweed starting 2013 until 2020. In Peninsular Malaysia, there were some efforts by the private sector to commercialise other seaweed species such as *Caulerpa* sp. and *Gracilaria* sp. However, there is limited and no access to information about how the private sector will commercialise seaweed farming. Therefore, the purpose of this study was to explore the current commercialisation of seaweed by the private sector in Peninsular Malaysia in terms of food security and healthier diets before, during and after the pandemic Covid-19. We used participatory approach and direct observation to collect data from seaweed farmers, policy makers, researchers, local community, chefs, and entrepreneurs. The study found that the *Caulerpa* sp. seaweed farmer went abroad before the pandemic to seek for seaweed expert due to unavailable local expertise. Through digital marketing, there was a rise in demand for *Caulerpa* sp. and *Gracilaria* sp. during the pandemic for direct consumption. After the pandemic, seaweed production has increased between 2021 and the present in Peninsular Malaysia despite a decline in East Malaysia's carrageenan seaweed production. This study suggests that, to achieve food security and better seaweed price, seaweed should be promoted as a source of better nutrition and healthier diets among consumers.

Abstracts

Status and prospects of seaweed farming in the Sulu archipelago, SW Philippines

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The commercial farming of seaweeds in the Philippines has grown significantly for the past fifty years to meet the world demand for carrageenan. However, the seaweed industry has been beset with various issues and challenges such as declining production and poor quality of raw dried seaweeds (RDS). This study assessed the farming and post-harvest practices of seaweed farmers in the Sulu archipelago using a mixed method approach—interview of key informants using a semi structured questionnaire, Focus Group Discussions (FGD), and household surveys. Farmers cultivate 52 varieties of *Kappaphycus* spp. at different times of the year using fixed-off bottom, floating and spring methods come from their previous harvest or bought from fellow farmers or seaweed traders or from the wild. A common problem in seaweed farming is ice-ice disease infection and epiphyte infestation. Ice-ice disease is observed during extreme changes in temperature and salinity, and when wind speed decreases and water becomes stagnant. There was widespread use of inorganic fertilizer. Fresh seaweeds are dried by sun drying them on platforms or by hanging method. These traditional methods of drying exposes seaweeds to contaminants and could lower raw dried seaweed (RDS) quality. The results of this study suggest that the RDS quality was affected by seedling quality, farming method, environmental conditions, and post-harvest method.

Abstracts

Healthy and bleached *Halymenia floresii* red alga: a microbiome assessment

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Complex host-microbiome interactions are fundamental for algal defence and resilience. Such interactions are prone to a paradigm shift from beneficial to detrimental when the alga is exposed to environmental stressors. We aimed at determining the bacterial community shift from healthy to disease (bleached) status to improve our current knowledge of the Florideophyceae *Halymenia floresii* - microbiome interactions and to explore how far the bacterial partners depend on the host health status. Thus, the structure and composition of *H. floresii*-associated bacterial partners were characterized through 16S rRNA gene high-throughput sequencing. Principal Coordinate Analysis, based on the weighted UniFrac distance, showed differences in the algal-associated bacterial community according to the host's health status. The bacterial communities of healthy, faded and bleached *H. floresii* was composed of 8 phyla, 10 classes, 21 orders, 27 families, and 24 genera. Shannon and Simpson alpha diversity indices vary from 2.4 - 4.0 and 0.90 - 0.97, significantly differing from the host's health status. In the healthy holobiont, the predominant phyla were Cyanobacteria (17-52%) and Proteobacteria (46-81%), Bacteroidetes (8-30%) and Proteobacteria (47-82%) being mainly observed in the faded and bleached host. Interestingly, in the healthy host, only one lineage, Novosphingobium (33-50%), was well represented, whereas their abundance was significantly reduced in the faded and bleached specimens (3-9% and 13-23%, respectively). This study firstly reports the bacterial partners of *H. floresii* related to healthy to bleached shift and improve our understanding of the changing microbiome on marine red algae and their potential ecological function.

Abstracts

Preferred macro-algal host-species of the two epiphytic dinoflagellates (*Gambierdiscus* and *Ostreopsis*) inhabiting Jeju Island

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We estimated the abundances of the *Gambierdiscus* spp. (GAMBI) and *Ostreopsis* spp. (OSTRE) from bimonthly macro-algal samples collected at 6 stations in Jeju for one year. GAMBI and OSTRE were quite contrasting in their substrate preference. Epiphytic dinoflagellates were observed in 72 of 81 species of substrate macroalgae when a total of 520 substrate samples was examined. GAMBI and OSTRE inhabited 20 and 58 of the 72 substrate species, with mean abundance of 601 and 596 cells g^{-1} wwt (CGT), respectively. Highest mean abundance of GAMBI (4730 CGT) and OSTRE (9870 CGT) was met at a brown alga *Hydroclathrus clathratus* and a red alga *Wrangelia tanegana*, respectively. Brown algae (*Dictyota coriacea, Padina arborescens,* and *Chordaria flagelliformis*) were among the top four substrates with high GAMBI abundance while red algae (*Polysiphonia* sp., *Hypnea* sp., *Anotrichium tenue*, and *Chondrophycus cartilaginea*) were with high OSTRE abundance. The contrasted substrate preference of GAMBI and OSTRE evokes further reasoning on their optimal adaptation to favorable biotic and abiotic habitat environments.

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Microplastics in seaweed farming area in Takalar waters of South Sulawesi, Indonesia

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Plastic pollution is a common environmental problem in many countries. Plastic waste ends up in the oceans and accumulates in smaller forms called microplastics (MPs). Takalar waters, located in South Sulawesi has several rivers flowing from residentials areas which contain MPs. Takalar waters also have a high potential for MPs due to the intensive seaweed farming in this area. Seaweed farming in Indonesia is known to have buoys of jugs, barrels, and reused mineral plastic bottles that produce MPs in the use for a duration of time in the sea. This study aims to study and see the presence of MPs in water and sediment; to identify the characteristics of microplastics including color, shape, and size in Takalar waters of seaweed farming and non-seaweed farming area. MPs identification was carried out visually using a Stereo Microscope (Euromex Stereo Blue 1902). The results showed that the microplastics found in the water and sediment samples in the first and second sampling were 519 MPs particles in both seaweed farming and non-seaweed farming area. From two sampling dates, there were 129 and 187 MPs particles were found in the water, while 104 and 99 MPs particles were found in the sediment. It was also found that MPs were more often found in the water and sediment of seaweed farming area compared to the non-seaweed farming area.

Abstracts

Development of iota-carrageenan/alginate composite films using processed stone sludge as a hardening agent

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Marine macroalgae are important renewable feedstock for important polysaccharides such as agarose, carrageenans and alginates, which, in turn, are widely used as thickeners and stabilisers in the food industry. Algal polysaccharides such as iota-carrageenan and sodium alginate are particularly interesting due to their ability to form insoluble gels in the presence of calcium ions. This presents an opportunity to contribute to the minimisation of the environmental impact caused by the waste residue generated by the stone processing industry [1,2], where the processed stone sludge can be used as a source of calcium ions for the hardening of iota-carrageenan/alginate composite films. With this in mind, we developed iota-carrageenan/alginate composite films hardened with processed carbonate rock sludge as potential replacements for single-use petroleum-based plastics. While the structural, chemical and antimicrobial properties of the developed films are currently under analysis, the films prepared with a carrageenan/alginate proportion of 75/25, in conjunction with D-sorbitol (plasticizer) contents ranging from 50 to 100 %, present a texture and flexibility similar to regenerated cellulose when dry. As such, these films may have a potential application as food packaging with low environmental impact.

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Abstracts

Antivibrio compounds from Indonesian red seaweed *Laurencia saitoi*

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Aquaculture is an important industry in supporting food security. Vibriosis is one of the problem in aquaculture industry that cause economic loss. Increasing incidence of vibriosis and escalating cases of resistance Vibrio spp to antibiotics have driven the searching for new antivibrio compounds. Red seaweed (Rhodophyta) is a source of secondary metabolites that have a broad spectrum of biological activity, and contain rich bioactive components that play a role in inhibiting bacterial growth. The objectice of our reseach to determine anti vibrio compounds and the molecular taxonomy of potential red seaweed from Gunungkidul, Indonesia. Extracts ethanolic were tested against *Vibrio parahaemolyticus.* The bioactivity was examined by in situ bioautography test and microplate assay using resazurin as an indicator. Bioactive compounds were detected using GC-MS and LC-MS. Dereplication of compounds was checked using database marine natural products. Molecular identification of seaweed was carried out based on amplification of the CO1 gene. Results showed that the potential red seaweed was identified as Laurencia saitoi with potential activity against *V. parahaemolyticus* at 0.078 µg/ml. The bioactive compounds were identified as aristolene and other new metabolites.

Abstracts

Gene expression modulation in atopic dermatitis and inhibition of Staphylococcus aureus adhesion by fucoidan

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Atopic dermatitis (AD) is a multifactorial debilitating skin condition that is associated with the bacteria *Staphylococcus aureus*, and alterations in the expression of genes involved in barrier function, itch and inflammation. Fucoidans are brown seaweed-derived sulfated fucose-rich polysaccharides that are known to be anti-inflammatory and may inhibit the adhesion of pathogens. Fucoidan was assessed for effects on gene expression of an *in vitro* 3D model of atopic dermatitis as well as inhibition of the adhesion of bacteria onto 3D reconstructed skin. Fucoidan significantly altered gene expression in the atopic dermatitis model, and there was a trend to reduce periostin levels. Fucoidan significantly inhibited the adhesion of *Staphylococcus aureus* and *Cutibacterium acnes* but did not affect the adhesion of *Staphylococcus epidermidis*. Fucoidan may be a useful topical agent to assist in the management of atopic dermatitis.