PHYCO MOVE

News letter

May 2019

ASPAB

AUSTRALASIAN SOCIETY FOR PHYCOLOGY AND AQUATIC BOTANY

Novel insights on steroid biosynthesis in diatoms

Kelp Lady travelling the world with Churchill Fellowship

OptoLeaf for Photosynthetic Photon Flux Density

Shellfish farmers joining the lab bench

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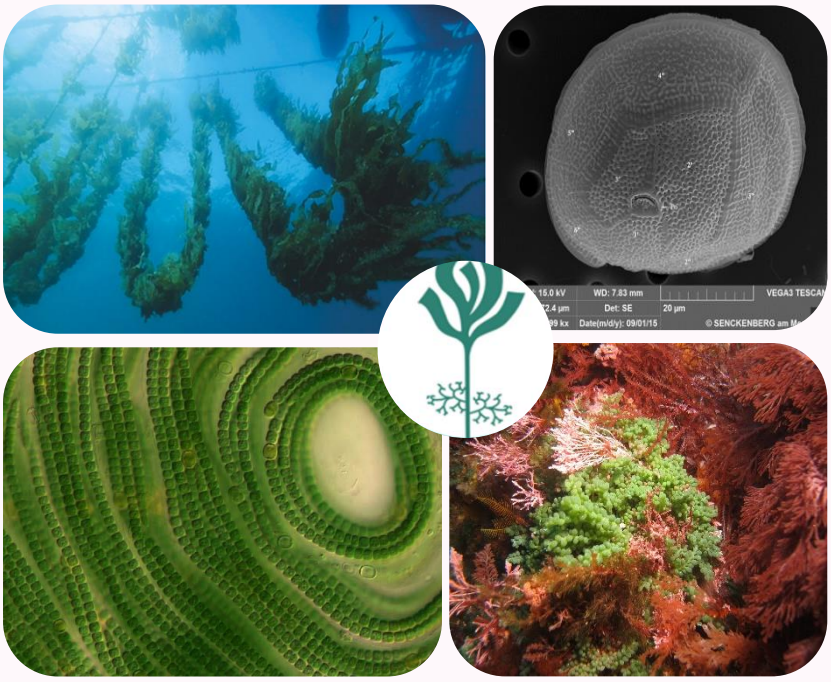

ASPAB Committee (2019)

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Australasian Society for Phycology and Aquatic Botany

The Australasian Society for Phycology and Aquatic Botany (ASPAB) is a professional scientific society, formally established in May 1980, that aims to promote, develop and assist the study of, or interest in, phycology (the study of macro- and micro- algae such as seaweeds and phytoplankton) and aquatic botany (the study of aquatic plants) within Australasia and elsewhere. Additionally, the society aims to establish and maintain communication between people interested in phycology and aquatic botany. To assist in promoting these aims ASPAB holds and annual conference, produces a newsletter biannually and maintains an email list for members (ASPAB-list).

Letter from the President

Happy Easter everybody! I hope you all had a safe and relaxing Easter break, enjoying it with family and friends.

I want to take this opportunity to thank all ASPAB members for electing me as president for the second term. Let me also thank the ASPAB committee who are working alongside me to service this society.

I also have to apologise for not having been in the position to host a well organised ASPAB meeting last year, as I just took up my new position at Flinders University as the Principal Research Scientist in the Centre of Marine Bioproduct Development and as the Research Director of the China-Australia Joint Laboratory for Native Bioresource Industry Innovation. The latter position requires extensive visits to China working with industry. I have to admit, I had no idea how difficult it turned out to be to communicate whilst in China – I was underprepared – no Google, a disaster when having a Google-based android phone.

Nonetheless, the meeting was held in Adelaide and, whilst small, it was inspiring to hear about the amazing research diversity carried out within the society. Congratulations to Zoë Brittain and Erin Cummings, who won awards for their oral presentations.

So, this year, the 33rd Annual ASPAB conference will be held in Wellington, New Zealand from the 11th to the 13th of November, and I am positive that this will be an outstanding opportunity for our student members to showcase their research.

As some of you are aware, ASPAB has been a member of the Science and Technology Australia (STA) for a number of years and the question was asked whether this membership is worthwhile for the members of ASPAB, in particular our New Zealand members cannot benefit directly. I had since several conversations with STA and, I guess quite rightfully so, it was pointed out that ASPAB had played a fairly passive role, not attending meetings or voicing issues that STA should address with government representatives. Therefore, in essence, no return on investment could be expected.

At the last AGM, we decided to maintain our STA membership for another year and to play a more proactive role. I attended the STA CEO forum, as the ASPAB representative, in Sydney on the 27th of March and had asked ASPAB members to provide me with aspects of their work that they would like to see more government support for. Unfortunately, I received no information prior to the meeting. The STA meeting opened with a vision statement by the main parties concerning their policies for investing into science and technology. In the afternoon, members were allocated to workgroups based on their society or company profiles to discuss issues/policies they want STA to influence in weeks leading up to the Australian election in May. ASPAB was assigned to the Environment workgroup, where I kept pushing the point that funding support is almost exclusively focussed on applied science, leaving basic scientific research and in particular taxonomic research strongly sidelined. I invite all members of ASPAB to reflect on whether or not environmental science is the core research carried out within the society, how we could utilise our STA membership more efficiently to influence political agendas and policies and what issues you experience that need to be resolved at the government level. In short use your voice and your membership in ASPAB to keep influencing the political agenda, so that our research area flourishes and keeps growing.

Together with you, I look forward to the future and hope that we will continue to influence and shape of phycology and aquatic botany for many generations of students.

JOANNA JONES STUDENT TRAVEL GRANT

Travel Grants support for ASPAB student members to attend conferences (but also workshops and laboratories) relevant to their research goals.

There are two rounds of applications a year.

Round 1 (due March 31st) *will target non-ASPAB meeting travel. Non-ASPAB meeting attendance travel grants will only be considered for PhD students, and only if they have previously attended an annual ASPAB meeting. Only one non-ASPAB meeting attendance travel grant will be awarded for each post graduate candidature.*

Round 2 (due August 31st) *will target travel grants to our annual ASPAB meeting in Australia or New Zealand.*

Deadlines: The applications, plus all documentation, are due to the Secretary of ASPAB, by March 31st and August 31st.

A maximum of AU$1500/NZ$1500 towards airfare and registration (no accommodation costs) is provided.

A student member can only apply for a travel grants once every 12 months.

The Applicant will be advised of the award outcomes **within 1 month of the deadline closing**.

Eligibility

(1) Applicants must have been an ASPAB member for at least 12 consecutive months prior to application (please check with the Treasurer if you are unsure).
(2) Applicants applying for funding to attend a conference must deliver an oral or poster presentation; if also attending a workshop or visiting a laboratory, they must indicate how the funds will advance their research goals.
(3) Applicants must be a student at the time of the award.
(4) Non-ASAPB-meeting-related travel grant applicants must state the year they attended an ASPAB annual meeting.

Application must contain:

1) A complete out application form (Student Travel Grant form)
2) A proof of Student Status letter on departmental letterhead, signed by the supervisor or Head of Department.
3) A confidential letter of recommendation for the primary supervisor (form available)
4) A CV from the applicant (2 page maximum).

For more information visit: https://www.aspab.org/fundingopportunities

ASPAB photo competition

Ready for closeup!!!

(Prize: $50)

submit photos to aspab.contact@gmail.com

Submit images of:

Macroalgae/
Microalgae/Seagrass/
Weird & Wonderful Finds

Competition will be held in August-19.

ASPAB will post the photos on Twitter, our Facebook page, Instagram and on the website.

Competition will run on social media for a total of 10 days.

The photo with the most likes over all three social media will be declared the winner.

Rules:

- *This competition is open to the general public.*
- *The participant must be the owner of the photograph without any non-exclusive rights.*
- *The participant must declare if there are copyright attached to the picture or any other regulation.*
- *The photos must not have been previously published.*
- *Only one submission is allowed per person per contest.*
- *If requested by the judges, the original material must be provided to verify the authenticity of the photograph.*
- *The winner will be selected according to the number of votes in all social media platforms.*
- *The participant allows ASPAB to use the photographs for advertising and non-profit diffusion of the association.*
- *If the image is use in any sort of printed or digital media, ASPAB is committed to acknowledge the photographer.*
- *The photographer retains all rights to use the photograph for any other purposes.*
- *The participant who break the rules or cheat will be disqualified*
- *The judges' decision is final.*

Metadata to be submitted with the photo

Title	
Photographer	First name, Surname, Institution
File name	e.g. IMG4567.jpg
Species	
Locality of the sample and date	
Brief description, photo-technique & post process, Other declarations	

CAWTHRON
The power of science®

Ph.D. Graduate student opportunity in microalgae cryopreservation and genetics

Supervisory Team
The Principal Supervisor is dependent on the preferred host university.

Co-supervisors available at the Cawthron Institute: Drs Lesley Rhodes, Kirsty Smith and Susie Wood.

The selected candidate will receive a PhD Scholarship comprising a 3-year stipend of NZ$25,000 pa (tax free), PhD/University fees and project costs.

New Zealand and international students are encouraged to apply.

Applications received on or before 30 June 2019 will be considered.

http://www.cawthron.org.nz

PHD OPPORTUNITY

We are seeking an enthusiastic and highly motivated student to undertake a fully-funded PhD project investigating the cryopreservation and genetics of the nationally significant Cawthron Institute Culture Collection of Microalgae (CICCM). The project will involve working with a multi-disciplinary team of environmental, molecular and chemistry researchers at Cawthron Institute, Nelson, New Zealand.

Context for the project
The CICCM is a nationally significant collection of marine and freshwater microalgae. The collection contains approximately 250 marine and 250 freshwater species spanning 14 different classes isolated from around New Zealand, the Pacific and Antarctica. The labour costs to maintain this living collection are considerable and can be reduced by cryo-preserving isolates. Cawthron has already led the world by cryopreserving the first dinoflagellates and many cyanobacteria, but we have been unable to cryopreserve larger and/or toxic marine species. Cryopreservation has the added advantage of preventing genetic drift, thus stabilising the production of valuable compounds.

Details of scholarship
Applicants with a strong background in biological sciences, including molecular ecology or a related discipline, and with demonstrated academic and research excellence at the Bachelor (Hons) or Masters level are encouraged to apply. The successful candidate must be able to work both independently and in a team. The successful applicant should be eligible to register for doctoral studies at a New Zealand university. The position will primarily be based at the Cawthron Institute (Nelson) but the student will be expected to spend periods of the studentship at their host University and with international collaborators.

The project involves microalgal culture, cryopreservation and molecular techniques. The student will play a key role in the project coordinating the various aspects of the research and addressing potential key research questions include:
1. Are cyst forms of marine microalgae more resilient to cryopreservation?
2. What new technology is available that could enhance cryopreservation success of microalgae? We anticipate that this part of the PhD will be undertaken jointly with collaborators in Europe.
3. Do the transcripts of key genes (i.e., those involved in toxin or high value compound production) and chemical profiles change after cryo-preservation?
4. Does the environmental source (i.e., tropical vs temperate vs. cold) or habitat (benthic vs planktonic) effect cryopreservation success?
5. Are there any key attributes (genetic or structural) that make some microalgae more amendable to cryopreservation?

Applicants should submit a cover letter with a statement of research interests and experience, a complete CV (including academic transcripts), and the names and contact information of at least two referees in a single PDF file, as well as a copy of their postgraduate thesis, by e-mail to Dr Lesley Rhodes (E: lesley.rhodes@cawthron.org.nz).

A Tale of two Enzymes: Novel Insights on the Evolution of Steroid Biosynthesis from Diatoms

By Dr Michele Fabris
Research Fellow,
Algal Biosystems and Biotechnology
Climate Change Cluster (C3),
University of Technology Sydney (UTS)
CSIRO Synthetic Biology Future Science Platform
Email : michele.fabris@uts.edu.au
https://www.uts.edu.au/staff/michele.fabris
ORCID: https://orcid.org/0000-0003-2910-2089
Twitter: @fabrismichele

Cover Photo credit: Penelope Ajani, UTS

All eukaryotes, living or extinct, originate from a primordial Last Eukaryotic Common Ancestor (LECA). Traits in common to eukaryotes across domains of life are likely to had been present in LECA, before eukaryotic life differentiated.

Steroids are essential components of eukaryotic membranes and are involved in the modulation of their fluidity and permeability. In many organisms steroids are also involved in cell-to cell signalling and defence. They form hormones in animals, such as testosterone, oestradiol, progesterone, and brassinosteroids in plants, which also use steroids as secondary metabolites (i.e. saponins). In diatoms, steroid derivatives regulate growth and blooms[1]. Since steroid profiles are specific to taxonomic groups, these molecules are considered useful biomarkers for present and past eukaryotic life. Their carbon skeleton can be preserved in fossilized sediments, and provide useful traces of organisms that inhabited past environments[2].

The steroid biosynthesis is an oxygen intensive process: eleven atoms of oxygen are necessary to synthetise one molecule of cholesterol in animals[3]. This metabolic pathway is a considered a hallmark of eukaryotic evolution and has been hypothesized that steroids emerged in response to the increasing during atmospheric and oceanic oxygenation by cyanobacterial oxygenic photosynthesis, around 2.3 billion years ago [2,3], which would support hypothesis that at least part of the pathway was present in LECA[4].

The biosynthetic pathway has been extensively studied for half a century, since Konrad Bloch and Feodor Lynen were awarded the 1964 Nobel Prize in Physiology and Medicine, "*for their discoveries concerning the*

mechanism and regulation of the cholesterol and fatty acid metabolism"[5,6]. Today, it holds little secrets in animals, plants and fungi and it became clear that enzymes and reactions of the steroid biosynthesis are conserved across domains of life, supporting the hypothesis that steroids were already synthetized by LECA. The degree of conservation is particularly high around the first reactions - the *core* - after which the triterpenoid skeleton gets decorated to yield more taxonomic-specific end products. The *core* reactions, which include the formation of squalene, its epoxidation and its subsequent cyclisation to a pentacyclic triterpenoid skeleton, are conserved in all steroid-producing organism[4] (Fig 1). The epoxidation of squalene is catalysed by the essential, highly conserved enzyme squalene epoxidase (SQE). This step represents a key marker of eukaryotic life, and no alternatives had been reported[3].

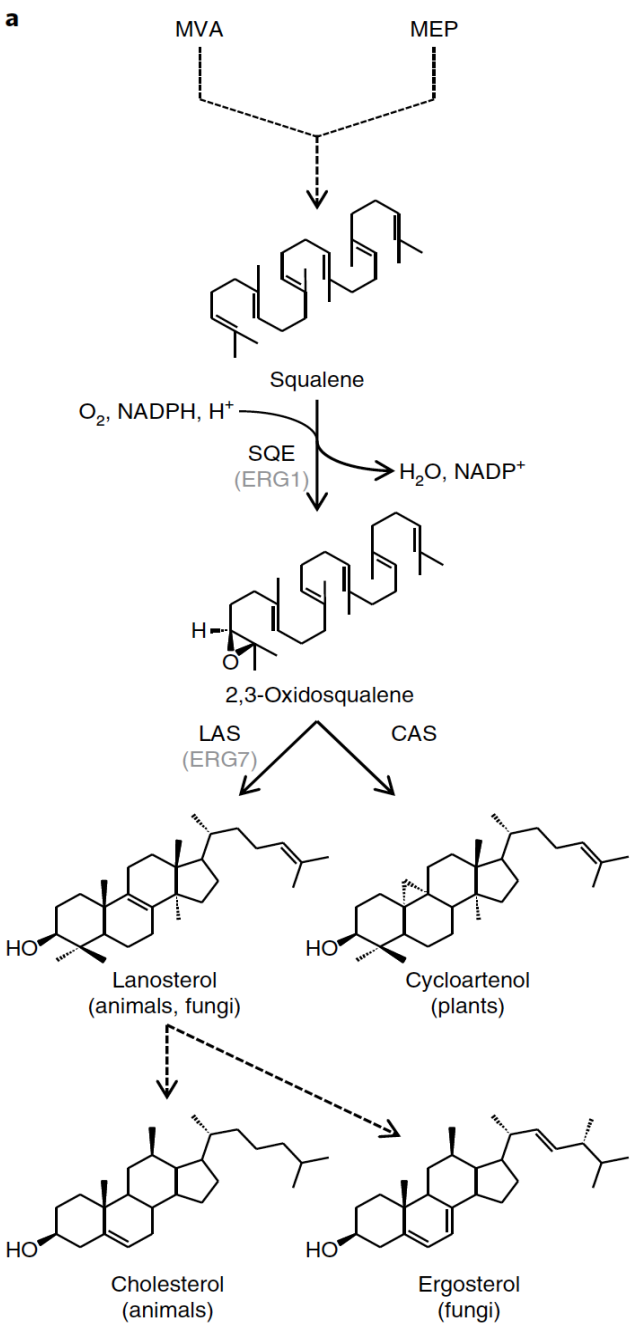

Figure 1. Conserved "core" reactions and enzymes in the biosynthesis of steroids

Now considered textbook biochemistry in plants, animals and fungi, the steroid biosynthesis pathway has often been assumed conserved in all eukaryotes. However, as more accessible sequencing technologies became available, genomes of increasing amounts of non-model organisms have been generated, making possible to question this in diverse phylogenetic groups, including microalgae.

To investigate the steroid biosynthesis in diatoms, we used the sequenced genome of *Phaeodactylum tricornutum,* biochemistry and functional genetics. We identified all steroid biosynthesis genes, except for the one encoding an SQE enzyme, which was clearly lacking. Yet, our experiments, showed that *P. tricornutum* synthetized steroids through squalene and epoxysqualene, like every other organism. Strikingly, the diatoms were insensitive to treatments with terbinafine, a potent and specific SQE inhibitor that quickly kills SQE-bearing organisms, such as yeasts[7]. Based on these results we hypothesized that *P. tricornutum* might use an alternative mechanism to carry out this reaction.

To answer this question, we employed a genetic complementation screen: by deleting the endogenous SQE-encoding gene from the baker's yeast *Saccharomyces cerevisiae* with CRISPR/Cas9, we obtained a strain that required ergosterol from the medium to survive, unless a gene encoding a functional SQE (or equivalent) was provided and properly translated by the yeast. Exploiting this principle, we introduced an entire library

of all the genes of *P. tricornutum*, and grew the resulting yeasts on medium lacking ergosterol. We obtained colonies that survived in absence of exogenous steroids, in which the SQE must have been restored by a diatom gene. We sequenced the DNA taken up by the surviving yeast colonies, and found out that a specific *P. tricornutum* gene was associated to them. This gene, *Phatr3_J45494*, encoded a fatty acid hydroxylase and, after subjecting it to thorough series of biochemical assays in mutant yeast and transgenic diatoms, we were able to conclude that it acted as completely novel type of squalene epoxidase, biochemically and genetically unrelated to the conventional SQE[8]. Nevertheless, it catalysed the exact same reaction, in a different way, involving different co-factors and a completely different chemical mechanism. Thus, we named it *alternative SQE (*AltSQE). Next, we analysed the phylogenetic distribution of it, searching against all available genetic databases[9]. Surprisingly, we discovered that the presence of AltSQE is not limited to diatoms, but is widespread across the Eukaryotic Tree of Life, with a patchy distribution within monophyletic clades, and mutually exclusive with SQE. We selected putative AltSQEs of representative species and we experimentally tested their activities in the mutant yeast.

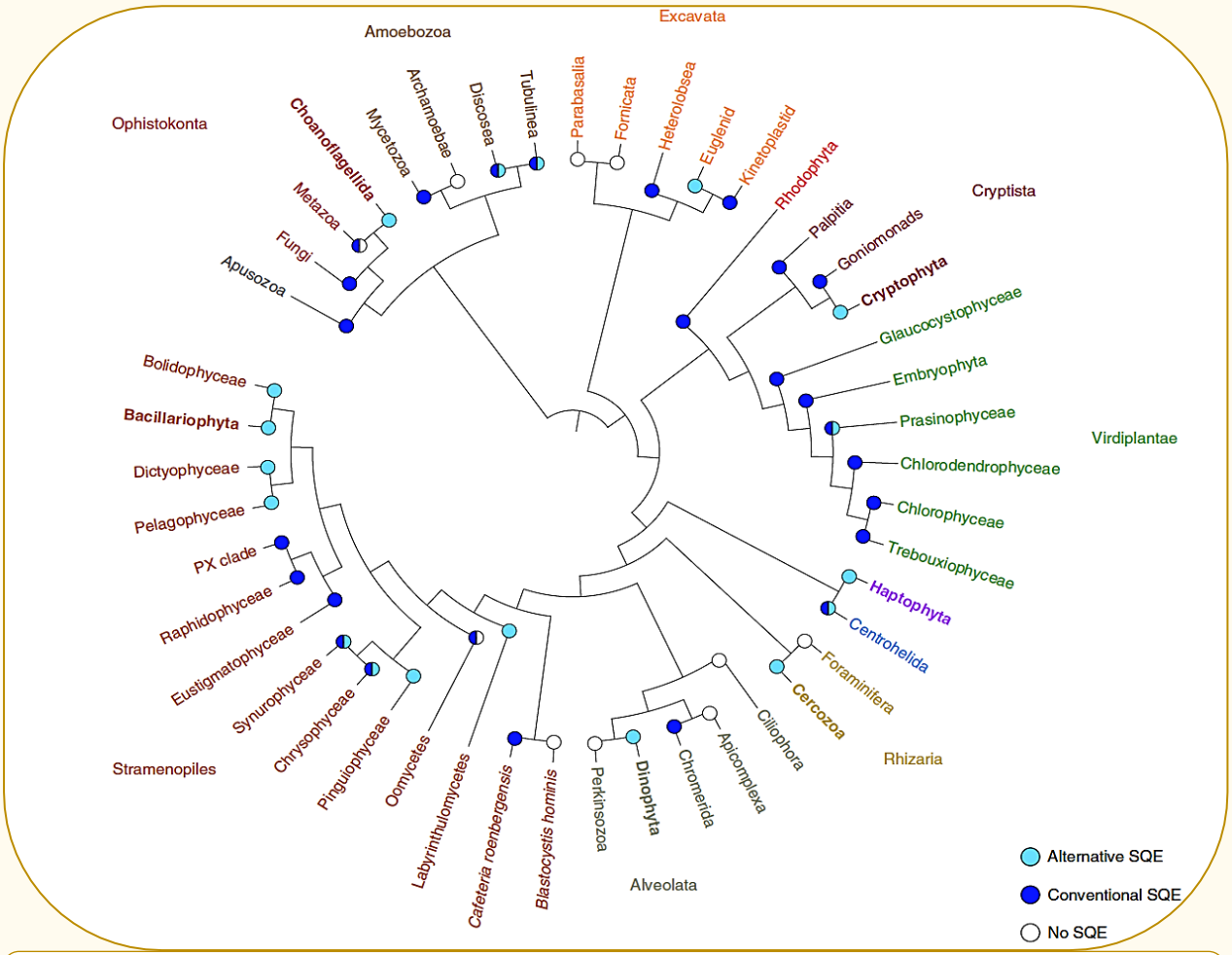

Figure 2. Phylogenetic distribution of the newly identified AltSQE (light blue) and the conventional SQE (dark blue) in the Eukaryotic Tree of Life

In the same way we confirmed the function of *P. tricornutum's* AltSQE, all these resulted able to catalyse the same reaction, confirming the widespread distribution of this enzyme.

Surprisingly, we identified a functional AltSQE in the genome of a virus that infects the bloom-forming coccolithophore *Emiliania huxleyi*. These viruses are known to override vital functions in their host. Curiously, one of the hijacked pathways is the biosynthesis of steroids, which the virus may need to assemble its envelope[10]. This virus causes massive *E. huxleyi* die-offs that could influence cloud formation[11]. For this, they may use their own AltSQE, which can thus be involved in massive-scale phenomena.

Although new research is required to understand what selective pressure and advantages determined the evolution of SQE or AltSQE in catalysing the same essential reaction, our findings already tell the story of an exceptional evolutionary case, in which an essential enzyme has evolved independently from a non-homologous and clearly distinct ancestor, as a mutually exclusive alternative to its conventional counterpart. This occurred in a wide number of taxonomic clades that span almost all branches of the eukaryotic species tree in a highly scattered fashion, raising important questions on the metabolic evolution of eukaryotes, and on the complexity of LECA[12].

Original research article: https://www.nature.com/articles/s41564-018-0305-5

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Interview: Role of Seaweeds in Sustainable Aquaculture

Dr. Craig Sanderson, seaweed enthusiast, entrepreneur and researcher, has a long-standing interest in the biology of seaweeds and commercialization of seaweed products, mainly from a Tasmanian perspective. He is currently working for the aquaculture company, Tassal Operations (https://tassalgroup.com.au/media/), to investigate farming seaweeds, including the Giant Kelp, *Macrocystis pyrifera*, that have the potential to offset any nutrients generated through salmon aquaculture.

Here, Dr. Sanderson (CS) talks with ***Dr. Matthias Schmid (MS)*** (Post-Doctoral Researcher at the Institute for Marine and Antarctic Studies (IMAS), University of Tasmania) about the new Cooperative Research Centers Project (CRC-P).

CRC-P project recently received $2.3 million CRC-P funding from the Australian Government's Minister for Industry, Science and Technology to research the seaweed culture proposition, growing techniques and products, to integrate seaweeds in a regionally relevant integrated multi-trophic aquaculture (IMTA) sustainable model ensuring economic, environmental and social benefits in Tasmania.

The steering committee of CRC-P projects involves Brad Evans (Tassal Operations), Catriona Macleod (IMAS), Craig Sanderson (Tassal Operations), Catriona Hurd (IMAS), Alecia Bellgrove (Deakin University) and Karen Alexander (IMAS)

MS: Hello Craig, can you give a brief overview of the new project "Seaweed solutions for sustainable aquaculture"?

CS: The project is funded as a Cooperative Research Centers Project (CRC-P) which will investigate the potential for using seaweed to reduce nitrogen output of salmon aquaculture in south-east Tasmania. The project involves optimizing the growth of seaweeds that might be suitable with some commercial potential and quantifying the amount of nitrogen which can be taken up by the seaweed. Currently Tassal works under a nitrogen cap, there is only so much salmon they can grow in the D'Entrecasteaux Channel due to the input of excess nitrogen. Using seaweeds could reduce the amount of nitrogen input into the channel.

MS: So the main goal is to use seaweed to take up excess nitrogen from the salmon farms, or are there any attempts to also utilize the seaweed biomass for commercial applications?

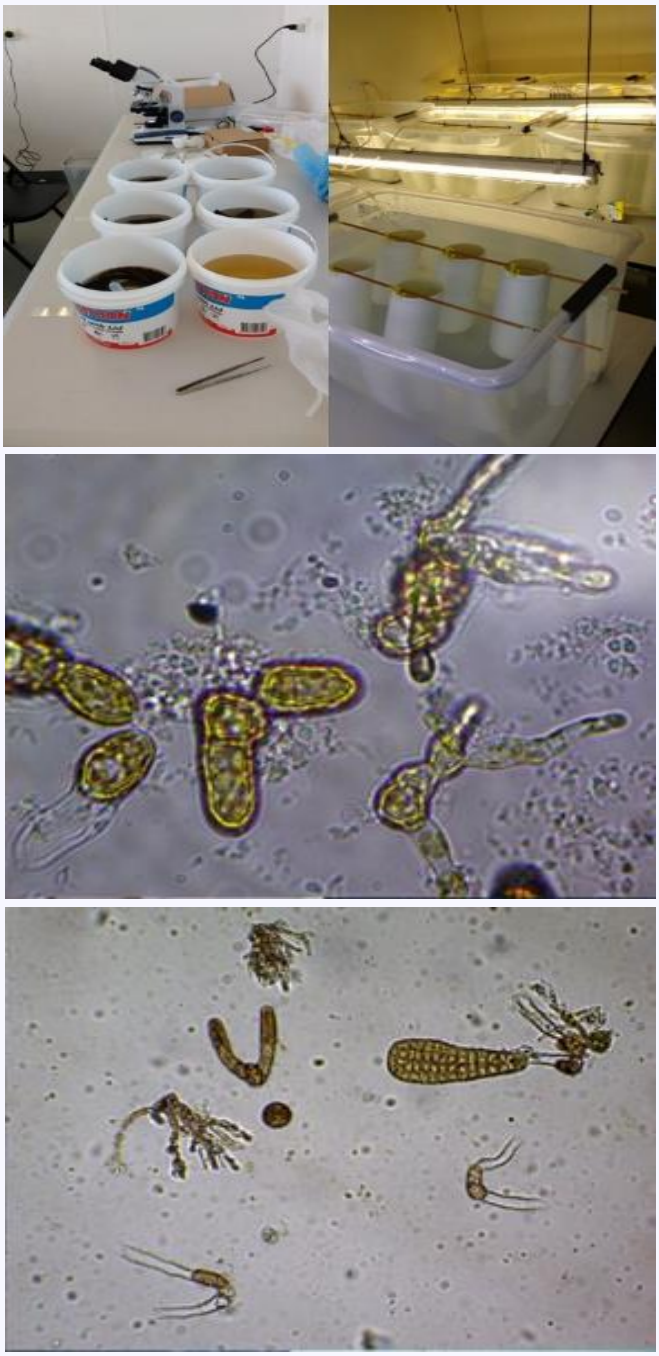
CS: The primary goal is the nutrient uptake. In the long term, if it is feasible to grow seaweeds adjacent to the salmon farms, it would be ideal to develop products from the seaweeds and initiate a seaweed industry around this biomass.

MS: As I understand it, this is a collaborative project with a number of different entities involved could you give an overview who is working together on this project?

CS: Yes, there are four partners on this project. There is Spring Bay Seafoods, Deakin University, IMAS and Tassal.

MS: There is also a very good representation of ASPAB members?

CS: Yes, Alecia Bellgrove from Deakin University and Catriona Hurd from IMAS are part of the research steering committee.



Spore release & their laboratory culture maintenance
(Photo Credit: Stefan Andrews and Craig Sanderson)

MS: IMTA is a topic which is always very popular amongst students. Are there possibilities for students to get involved in this project, for example PhD or honours projects?

CS: Yes, there will be four PhD students within the project.

MS: What are the specific research areas the PhD students will be focusing on?

CS: The project is planning on working with three Laminariales: *Ecklonia radiata*, *Macrocystis pyrifera* and *Lessonia corrugata*. All of these species are large biomass plants and culture techniques of growing Laminariales are well established. These techniques will be adapted to the local species and conditions. One of the PhD students will be working at optimizing the hatchery techniques for the three species.

The second PhD student will be looking into optimizing the production of kelp on longlines. Furthermore, there will be two PhD students in the social sciences, of which one will be looking into modelling of the nitrogen uptake of the seaweeds. Another aspect of this PhD will be to understand where to place farms in relation to the salmon aquaculture to achieve optimal nutrient uptake by the seaweeds. The fourth PhD will be looking into social impacts of the seaweed aquaculture.

MS: It's great that there are so many opportunities for students to get involved. Are there any resources online for students to get more information about those opportunities?

CS: We are currently aiming on having the available positions advertised on the IMAS website and also via the Algae-L list-server. The four PhDs will be based at IMAS as well as two technical assistant positions, in addition there will be a Post-Doc at Deakin University.

Nursery culture of juvenile Sporophytes and subsequent cultivation in the ocean
(Photo Credit: Stefan Andrews and Craig Sanderson)

MS: Are there plans of using the seaweed biomass in this project?

CS: Tassal has taken the initiative, a few years back, to establish kelp aquaculture in Tasmania and start growing Laminariales on longlines. Current goals are now to optimize production and maximize the amount of kelp biomass and investigate potential uses of the seaweed biomass. Potential uses of the kelp biomass include food applications, but also as a resource of fucoidans, alginates and plant stimulants to name a few. The potential utilization of the seaweed will largely be determined by the quality of the seaweed biomass which can be achieved.

MS: You are heading to the International Seaweed Symposium in South Korea in a couple days. South Korea has a long-standing tradition of using seaweeds and seaweed aquaculture, is there anything specific you are interested in with regards to the new project?

CS: My understanding is that the main seaweed aquaculture in Korea focusses on Porphyra but considering the long and well-established expertise in seaweed aquaculture, there is a lot to learn from the industry in south-east Asia. Especially, their ability to grow seaweed at large scales and also the variety of commercial products derived from the seaweed will be very interesting.

MS: Coming back to Tasmania. Tasmania's population of Giant kelp has decreased significantly in recent years. Are there any approaches for using some of the seaweed stock from the project to support natural populations along the Tasmanian coastline?

CS: Currently there is a local dive operation in south-east Tasmania, Eagle Hawk Dive Centre, which was established to provide diving opportunities in the local giant kelp forests. In recent years most of these giant kelp forest have disappeared, most likely due to warmer water temperatures. We are doing trials to explore whether we can use some of the excess juvenile plants from the aquaculture to out-plant. So far, we have had some good success and it is also a great opportunity for local divers to be involved and learn about seaweeds.

MS: Where do you see the Australian seaweed aquaculture in 20 years?

CS: It would be great to see a matured seaweed aquaculture industry – including seaweed aquaculture that provides tools to reduce nutrient input from anthropogenic influences. An advantage of having diverse aquaculture, which is made up of a variety of different species, is that it enables greater resilience for farmers rather than focusing on one species. It would be great to see a mature Australian seaweed industry which is sustainable and environmental friendly.

ALGAE PRODUCTION FOR HIGH VALUE PRODUCTS

Dr. Leen Labeeuw (Research Fellow),
Climate Change Cluster (C3), University of Technology Sydney,
leen.labeeuw@uts.edu.au

We are investigating the scalable production of algae for the production of biopharmaceuticals, for use in the increasingly popular and flexible single use technologies system. We have designed a single use cGMP-lite facility for the production of 200L algae with the subsequent downstream processing for high value products.

Algae are an amazingly diverse group of photosynthetic organisms that have a range of important ecosystem functions. However, it is only recently that we are starting to tap into their exciting biotechnological potential. While microalgae have long been touted as a possible biofuel source, the economically sustainable production at scale remains elusive[1]; there is however a world of opportunity in high-value products. There is an increasing amount of research into how to modify algae to produce high value products, such as biopharamceuticals[2]. However, one of the major challenges facing the biotech industry is the ability to scale up production of these axenic, genetically engineered strains under conditions that will fulfil regulatory requirements, such as current good manufacturing practice (cGMP) for biopharmaceuticals.

There is a trend in pharmaceutical production away from large stainless-steel facilities that are dedicated to producing only one product. Single use technologies offer more flexible operations and are becoming increasingly common in the pharmaceutical industry. They have the advantage of lowered capital costs, reduced cleaning cost, and faster turnaround time[3]. As such, to address the gap in algal bioprocessing, and in collaboration

Prototype algal bioreactor with light and internal sensors. The light distribution, gas transfer and fluid dynamics are being modelled to improve production.

with General Electric (GE) Healthcare Australia, we are investigating the upstream processing requirements for a cGMP compliant, single-use photobioreactor and the subsequent downstream processing. The single-use GE WAVE 25 bioreactor has been shown to be an effective cultivation system for yeast, bacterial, and mammalian cells, and we have shown it to be suitably adapted to cultivation of a marine diatom with the addition of illumination, temperature control, and optimized

gas mixing. This culture can then be used as the inoculum for a larger scale single-use bioreactor, such as the GE XCellerex system, which is also being investigated for conversion into a photobioreactor.

One of the challenges of a large scale photobioreactor is ensuring optimal mixing and light transfer within the system. Researchers at C3 have developed a novel method to map out the light distribution within the bioreactor to optimize the placement and usage of the LED lights. We can then integrate that with computational fluid dynamics (CFD) modelling of the bioreactor to better understand the conditions the algae find themselves in, and how to optimize their growth and production of the pharmaceutical.

Harvesting remains one of the challenges with the algal species. There are few single use harvesting systems available that are suitable for algae, which have similar density to water, are relatively dilute, but are still sensitive to shearing. While our work to improve cell concentration in the bioreactor is helping somewhat, more research is needed into improved harvesting techniques that are suitable for algae and fit within the single-use processing facility. To that end, we are testing various filtration techniques, which do not damage the cells and can effectively concentrate the algae.

Using these successful demonstrations of the single-use manufacturing process for use in algal biotechnology, UTS:C3 has designed a pilot scale (200L) cGMP-lite single-use processing facility for the full production of algal derived high-value complex biomolecules such as pharmaceuticals. Due to open in June 2019, it is the first of its kind in the southern hemisphere and will be used to train students and technicians in single use technologies, as well as demonstrate the viability of algae as a vector for the production of high value products.

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cGMP lite facility with upstream production with a 200L vessel, midstream for harvesting, downstream for purification, and fill and finish room. All parts of the process are single use, allowing for flexible operation and faster turnaround time.

What's happening in the Deakin Seaweed Research Group?

Left to right: *Dr Jacqui Pocklington, Erlania, Erin Cumming, Dr Prue Francis, Dr Alecia Bellgrove, Vanessa Skrzypczyk, Zoë Brittain;* Upper right: *Rachael Cook; Lower right: Zuraya Naga*

New Grants and Awards:

Seaweed solutions for sustainable aquaculture. $5,468,110 CRC-P

Tassal Group Limited; Deakin University; University of Tasmania; Spring Bay Seafoods Pty Ltd

This project will develop a sustainable Integrated Multi-Trophic Aquaculture (IMTA) model that supports commercial seaweed production. To do this, the research will i) define the seaweed culture proposition (identify species, growing techniques and products) and ii) develop a regionally relevant IMTA partnership model that brings together salmon, shellfish and seaweed producers to ensure economic, environmental and societal benefits. There will be four PhD projects based at IMAS (University of Tasmania) and one post-doc position based at Deakin University Warrnambool Campus associated with this project. Keep an eye out for advertisements coming soon!

Future Proofing Australian Agriculture with Seaweed Supplementation. $109,000

Demo Dairy Foundation and Deakin University partnership

This project will support a PhD that will combine phycology, advanced analytical chemistry, microbiology and agricultural science to examine the effects of supplementing dairy cow diets with local seaweeds on 1) milk yield and quality, 2) animal health, c) carbon emissions and 4) farm-scale water budgets. The research will help assess the potential for seaweed supplementation of livestock to simultaneously drought-proof the Australian dairy industry and address carbon emissions.

Bill Borthwick Scholarship of $2500 awarded to PhD student, Erlania

Biomarker development for detection and quantification of seaweed carbon in marine sediments *(see project description below)*

Current Student Projects:

Erin Cumming (PhD candidate): *Developing seaweed production techniques for* Phyllospora comosa

The global market for seaweed products is well established with an exponential increase over the past 50 years. Seaweeds in Australia are being recognised for their potential as both a food source and potential bioremediation abilities. The fucoid *Phyllospora comosa* has sparked interests from industry as a potential commercial aquaculture species in Sothern Australia. However, information of the feasibility of culturing this species, remains limited. This project investigated optimal spawning conditions through a series of spawning events testing; lunar phase, light, temperature and exposure continuing with optimal seeding twine based on a range of synthetic twines and one natural twine. The final component of this study was to identify the optimal location and depth for seaweed deployment through transplanting trials and hydrodynamic data collection.

Vanessa Skrzypczyk (PhD candidate): *Sustainable solutions using Australian seaweeds: nutritional profiles and potential for heavy metal contamination*

Seaweeds are becoming increasingly popular as healthy functional foods in western countries. Due to this increased interest, it is important to ensure that seaweeds are harvested/produced sustainably without any negative impact on the environment or on human health. The scope of this project is to assess the chemical profiles of Australian seaweed species with commercial potential for compounds such as polyunsaturated fatty acids, sterols, and dietary minerals; all of which are beneficial to human health. However, most importantly is the consideration that seaweeds are very efficient at absorbing minerals and toxins from their environment. Whilst Australia has a 'clean and green' image, we are also assessing the potential for heavy metal pollutant toxicity in seaweeds harvested from urbanised Australian shores to determine any potential human-health risks and safety concerns.

Erlania (PhD candidate): *Contributions of seaweed to carbon sequestration*

Global carbon emissions have contributed to a rapid increase of atmospheric CO_2 and led to global warming and climate change. Carbon mitigation strategies are crucially required to deal with this problem. Marine bio-sequestration has been recognized as an essential part of the solution since more than 50% of atmospheric C is eliminated by marine organisms, including seaweeds, controlled by photosynthesis. Seaweeds have amongst the highest rates of primary productivity and store significant amounts of C in living biomass. What is uncertain is the fate and longevity of all this seaweed-derived C. Incorporating seaweeds into Blue Carbon (BC) strategies has remained controversial as they grow on hard substrata and thus do not facilitate accretion of carbon (C) within their habitat. However, seaweeds may be significant C donors to carbon sink ecosystems. This project will develop a suite of biomarkers (based on environmental DNA (eDNA), fatty acids and amino acids) to detect seaweed C in marine environments. Combining developed biomarkers with stable isotopes will enable quantification of seaweed C in sediment. This will then be used to detect and quantify seaweed C contributions to carbon sequestration in marine sediment cores based on predictive modelling of seaweed beds proximity to BC sinks and coastal hydrodynamics.

Zoë Brittain (Honours student): *Learning from Communities: can historical Indigenous uses of seaweeds inform a sustainable Australian seaweed industry*

My research explores the depth of traditional ecological knowledge (TEK) held by Indigenous peoples related to seaweeds and the uptake of this knowledge by seaweed industries through 1) reviewing the global scientific and anthropological literature and 2) collecting oral histories with Indigenous Elders/knowledge holders in south-eastern Australia. Global review revealed that Indigenous traditional knowledge includes a wide variety of uses and management techniques that may benefit commercial seaweed industries. Moreover, oral histories and traditions of Australian Saltwater Peoples are rich with knowledge of seaweed use. However, in 81% of industry projects that have used Indigenous TEK, the Indigenous communities responsible for such knowledge received no clear benefits. Ongoing research, informed by global trends, successes and mistakes, prioritises collaboration with Australian Indigenous Elders, and aims to inform future collaboration between seaweed industries and Australian Indigenous peoples for mutual prosperity.

Zuraya Naga & Rachael Cook (3rd year and Honours students): *Predicting the response of marine foundation species to a changing climate*

Australia's unique marine ecosystems are directly threatened by climate change. Effective conservation planning is dependent on our ability to predict the resilience of ecosystem engineers to environmental change, as their response will have the greatest influence on community dynamics and structure, and ecosystem function. Using a foundation macrophyte species from south-eastern Australia, it will be demonstrated how adaptation experiments can be integrated to determine adaptive capacity and future population trajectories. Outputs from this project will provide immediate benefits for marine conservation planning and a framework for facilitating international marine adaptation research. Laboratory-based temperature stress experiments and common garden experiments will assess the adaptive capacity of early developmental stages of *Hormosira banksii* and their vulnerability to the changing climate.

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Shellfish farmers joining the lab bench: The detection of toxic *Alexandrium* species using QPCR Approach

Rendy Ruvindy[1], Mark Vanasten[2], Shauna Murray[1]
[1]Climate Change Cluster,
University of Technology Sydney, NSW, Australia
[2]Diagnostic Technology Pty Ltd, Sydney, NSW, Australia
Email: Rendy.Ruvindy@uts.edu.au

A bloom of a species of Alexandrium, A.catenella, in Tasmania, Australia in 2015 resulted in four tourists being hospitalized due to Paralytic Shellfish Poisoning (PSP) after consuming wild oysters, raising concerns of wider public health impacts.

Blooms of dinoflagellates producing Paralytic Shellfish Toxins (PST) are a prevalent and persistent issue affecting shellfish harvesting around the world. Particularly in Tasmania, Australia, PSTs have impacted shellfish farms financially through closures and product recalls, resulting in employment terminations and brand damage (1).

Previous species characterisations of shellfish harvesting areas in Tasmania indicated the prevalence and co-occurrence of almost identical toxic and non-toxic species of the former *Alexandrium tamarense* species complex (*A. catenella*, *A. pacificum*, and *A. australiense*), three species which cannot be differentiated using light microscopy (2). Therefore, phytoplankton-monitoring using light microscopy and total PST in shellfish using High Performance Liquid Chromatography (HPLC) are not able to provide an early warning capacity allowing for preventative management decisions.

In my PhD project, I investigated the use of quantitative Polymerase Chain Reaction (qPCR) assays as an accurate and efficient in-field early warning system, as well as a tool for long-term risk assessment and population dynamics.

In this project, I showed that rDNA-based assays and those based on a gene required for toxin production (*sxtA4*) were specific, sensitive and efficient. The efficacy of rDNA-based assay for cysts quantification have also been demonstrated, showing their potential to be used as a long-term risk assessment tool for a new harvest area (3).

rDNA-based assays have been shown to overestimate cell quantification, and my results confirmed that (3). rDNA and *sxtA4* copy number variation within species of *Alexandrium* appears to be the cause of the mismatch between the copy number per cell of strains in the environment and those used as standard curves. The *sxtA4*-based assay was more accurate than rDNA-based assays when used to quantify toxic species in seawater.

I also developed and validated a commercial pipeline based on *sxtA4* that can be used in the farm by shellfish farmers. With the emergence of small, portable qPCR platforms within the past 10 years, it is now becoming feasible to conduct qPCR in the field.

By combining a portable qPCR platform with simplified sample collection and processing, it was demonstrated that a pipeline could be developed for use on-farm by a commercial mussel farm. Using this pipeline, *sxtA* copies indicative of the presence of PST-producing species were found to be present two weeks before detectable PSTs were found in mussel tissue.

Given that the PST analyses itself required several days, acquiring the information on *sxtA* presence and abundance two weeks previously allowed the aquaculture operator to make a significant management decision, in this case to voluntarily close harvesting and resume harvesting from another mussel harvest area. The weekly *sxtA* qPCR analyses showed the continued abundance and decline in abundance of *A.catenella*, providing information used to determine when production could resume in the affected area.

The integration of *sxtA* based qPCR assay pipeline into a phytoplankton monitoring program can be a possibility in the future. The availability of a liquid handling robot and the qPCR platforms that can accommodate a 384 well-plate can significantly enhance the sample processing capacity.

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OptoLeaf: Measure Photosynthetic Photon Flux Density using a Light Sensitive Film

***Dr John W. Runcie*[1,2]**
[1]*School of Biological Sciences, University of Sydney NSW 2006*
[2]*Aquation Pty Ltd, PO Box 3146 Umina Beach NSW 2256*
john.runcie@aquation.com.au *john.runcie@sydney.edu.au*
http://www.researchgate.net/profile/John_Runcie/
http://www.linkedin.com/profile/view?id=11715301

OptoLeaf attached to *Posidonia australis*

Photosynthetic photon flux density (PPFD) plays a pivotal role in the growth and survival of photosynthetic organisms. Light is often strongly attenuated in coastal aquatic and marine environments where macroalgae, seagrasses and corals are commonly found. Understanding light availability in these submerged environments is key in interpreting growth rates, photosynthetic performance and determining the capacity to tolerate stress.

Direct measurements of PPFD can be achieved using quantum sensors. However, this approach is expensive, obtrusive and impractical for simultaneously sampling multiple locations.

- ✓ *A colour acetate film treated with azo dye offers a useful alternative where multiple unobtrusive measurements need to be made, as the thin film can be easily attached to small leaves.*
- ✓ *The absorbance of the dye gradually fades with light exposure, and the rate of fading correlates well with PPFD. Ideally, multiple pieces of film are deployed in the field along with a few samples directly adjacent to a logging quantum sensor.*
- ✓ *Fading rates of the reference samples can then be compared with measured quantum dose derived from the quantum sensor. This relationship is then used to convert fading rates of all samples in the field to total photon dose.* ***The film is available as "OptoLeaf".***

Underwater applications

The film can be used underwater (e.g. Hirano et al. 1996). Small strips (1 x 2 cm) can be attached to seagrass blades or macroalgae with stainless steel staples or clips. As the film is thin (~0.1 mm), and light (<1 g per strip) it has minimal impact on the movement and buoyancy of a seagrass blade or macroalgal thallus. Therefore, samples can be placed in a multitude of orientations and depths within the canopy. By measuring the absorbance of each sample prior and post deployment, one can determine the rate of change of absorbance. This rate of change can then be expressed in terms of total photon dose by use of a reference curve. Reference curves can be generated independent of a field experiment as long as the temperature and light conditions are similar. Systems where the film could be usefully used include:

- Seagrass meadows
- Macroalgae beds
- Benthic microalgae mats
- Coral reef systems
- Suspended in the water column (downwelling and upwelling irradiance)
- Horizontal and vertical surfaces, etc.

Case studies – terrestrial

Numerous studies have been conducted with terrestrial plants, for example:

- A method for evaluating the interaction between individuals competing for light in a monospecific stand (Hikosaka et al. 2001) – this method could be directly relevant in assessing how seagrass blades shade one another.
- An assessment of forest understory PPFD over a 12-month period including changes in ambient temperature over the year (Kawamura et al. 2004) – the study concluded that the accuracy and low cost of the film made it a good option for estimating the integrated PPFD in a forest understory.

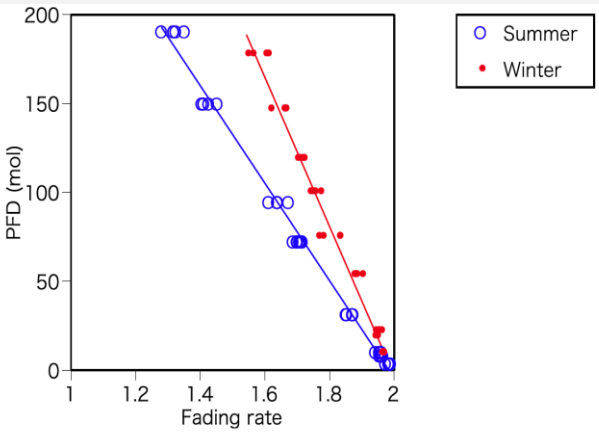


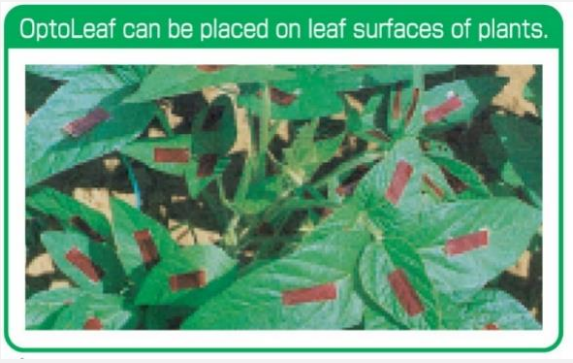
Fig. 2. Calibration lines to estimate PFD from fading rate of the film. The lines differ significantly between summer and winter in Kyoto, Japan (summer, r = 0.99; winter, r = 0.98).

Image from http://prometheuswiki.publish.csiro.au

- The detection of novel quantitative trait loci controlling photosynthesis by increasing leaf nitrogen content and analysing its effect on leaf and canopy photosynthesis (Hirotsu et al. 2017)

Availability

Aquation Pty Ltd now distributes OptoLeaf for Taisei Fine Chemical. Co., Ltd. (Japan). Three different films are available (1 to 3 days, 3 to 7 days, 1 to 3 weeks). While the 1-3 day tape is more accurate, some users prefer the 1-3 week tape for longer integration intervals. Handheld readers are available, or a spectrophotometer can be used. https://aquation.com.au/products/optoleaf/.



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The Southwards movement of Ciguatera Fish Poisoning in Australia

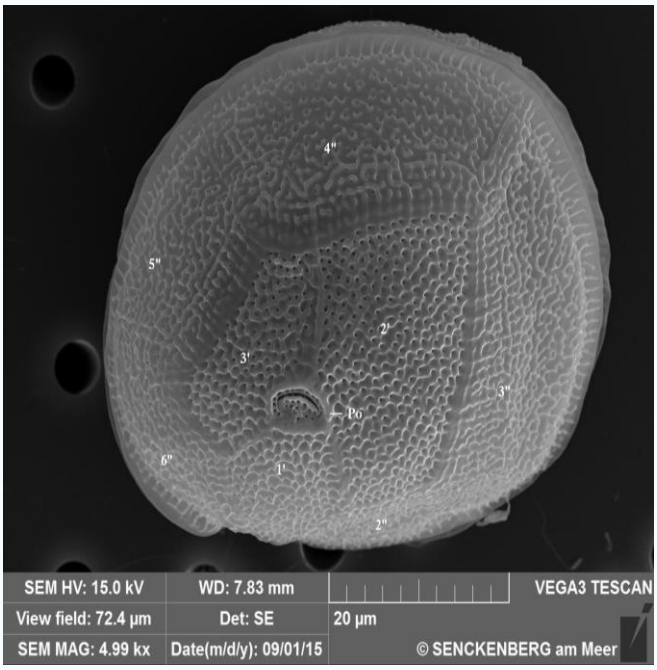
A/Prof Shauna Murray *(Shauna.Murray@uts.edu.au)*
Climate Change Cluster, University of Technology Sydney, Sydney, NSW, Australia

Ciguatera Fish Poisoning (CFP) is a human illness which occurs through the consumption of fish that have accumulated naturally occurring ciguatoxins (CTXs), a type of toxin produced by species of the marine dinoflagellate genus *Gambierdiscus*. It is one of the most common seafood-borne illnesses internationally, and has been of growing concern worldwide.

In Australia, cases of CFP have occurred principally due to fish caught in tropical Queensland and Northern Territory waters, including tropical reef and pelagic fish. Spanish mackerel (Scomberomorus commerson), a pelagic fish, is one of the fish species that has been most commonly involved in Australian CFP cases.

In Australia, several thousand cases of the illness have been documented over the past 40 years, including two fatalities (1,2). As the reporting rate of this illness is thought to be around 10% or less, that would amount to around 300 cases nationally per year.

Prior to 2014, only one outbreak of CFP had been reported from a fish caught south of the Queensland border, a fish from Brunswick Heads, close to the QLD border, caught in 2002. However, in the five years since 2014, seven outbreaks have occurred, impacting ~25 people, including one outbreak from a fish caught at Crowdy Head, NSW (3).



While traditionally considered as a tropical or sub-tropical disease, CFP has become an emerging issue in locations previously thought to be outside its range of impact. Increasing ocean temperatures and the intensification of the southward flow of the East Australian Current may have influenced the migration of Spanish mackerel, as well as the distribution and growth of CTX-producing *Gambierdiscus* species.

The identities, distribution and toxicity of *Gambierdiscus* species in Australia are little known. Recent work has identified the presence of two new species of *Gambierdiscus, G. lapillus* and *G. honu*, at Heron Island in the southern Great Barrier Reef (4,5). The distribution and toxicity of species of *Gambierdiscus* from CFP 'hotspot' sites in Australia remain to be investigated.

A recent ARC Linkage project has recently been awarded to myself and collaborators, A/Prof Chris Bolch, Prof Richard Lewis, Dr Tim Harwood, to investigate Gambierdiscus and CTXs in Australia, and their link to CTX in marine fish species. As part of this project, we will be conducting field trips to collect samples and culture Gambierdiscus from in tropical and sub-tropical locations in eastern Australia.

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Young Scientist Exchange Program (YSEP) fosters collaboration between Australia and China

Marine molecular biologist, ARC-DECRA Fellow at UTS Climate Change Cluster, ***Dr Manoj Kumar*** was one of only sixteen Australians chosen to participate in the 2018 Australia-China Young Scientists Exchange Program (YSEP).

Email: manoj.kumar@uts.edu.au

YSEP is a joint initiative by Australian and Chinese Governments under the Australia-China Science and Research Fund (ACSRF) and organized by China Science Technology exchange center (CSTEC) and Australian Academy of Technological Sciences and Engineering (ATSE).

Dr Kumar said that the two-week exchange program provided a great opportunity to visit leading Chinese Marine Science Institutes including Institute of Oceanology, Chinese Academy of Sciences (IOCAS) in Qingdao; several State Key Marine Laboratories of CAS in China. "YSEP was unique in giving me the chance to meet high-profile and pioneer Chinese researchers and their team members working to address the global concern of resilience and persistence of marine plants and algae under global warming and climate change," he said.

"I was also able to discuss the range of scientific research grants, fellowships, scholarships and awards available for the potential exchange of Australian and Chinese researchers including the Endeavour program, opportunities from Department of Foreign Affairs and Trade, and the Global Connections Fund (GCF) which is a new initiative from ATSE for researchers and SMEs collaboration to translate research knowledge and intellectual property into market-ready products or services," he said.

As well as delivering several guest lectures at these organizations Dr. Kumar met with researchers and students, introducing them to the innovative systems biology approaches to protecting marine flora he has been developing at C3. Dr Kumar uses cutting-edge omics (proteomics and metabolomics) to identify biomarkers that can be used to monitor the health of important marine flora under threat from global climate change.

"Not only is YSEP is a great way to promote an understanding of the cultures of the two countries and to exchange expertise and innovative ideas but the scheme also brings together future science leaders to foster short to long term collaboration between Australia and China," he said.

Visit link below for YSEP-19 program application

https://www.applied.org.au/ysep-applications-2019/

"Kelp Lady" awarded Churchill Fellowship to travel overseas

***Jo Lane** is thrilled to have received the prestigious Churchill Fellowship to travel overseas to "Investigate appropriate methods for introducing kelp farming aquaculture to Australia."*

Her tour will begin in Korea at the International Seaweed Symposium from April 27 – May 3. She then plans to travel to Ireland, Scotland, Faroe Islands, Norway, USA and Canada to meet with kelp farmers, scientists, and seaweed enthusiasts to bring new knowledge and inspiration back to Australia. "This is an incredible opportunity made possible by the generous support of the Yulgilbar Foundation, which specifically supports projects with a regional and environmental focus".

Jo studied marine biology and Environmental Science at Macquarie University, Sydney. She moved to south coast NSW in 2002, and worked for Coastcare, National Parks, and also NSW Fisheries. It was whilst working for Fisheries, Jo became aware of a kelp harvesting business called Sea Health Products, when she had to process their collection permit. Her interest in seaweed was ignited and several years later in 2015, she purchased the business when the owners retired and moved from the area.

Jo believes "Sea Health Products may well be Australia's first seaweed business, started in the late 1960's by the original Kelp Lady - Betty Long. Betty's son, Scott and his partner Pip, moved to Narooma to keep the business going and when they retired, Jo was there to continue the legacy! Jo hopes Betty would be pleased with the direction the business is headed.

Sea Health Products has a permit to collect two species – *Ecklonia radiata* and *Phyllospora comosa*. The Crayweed or *Phyllospora* is used in their bath soaks, whilst the Golden Kelp or *Ecklonia* is used for food products such as kelp granules and powder.

Kelp, a type of brown seaweed has so many health benefits and is an extremely versatile resource. As demand grows it may become difficult to rely on sustainable wild harvest. Kelp farming could be the answer!

Well established overseas, kelp farming is also referred to as 'restorative farming' as it requires no freshwater, no land and no fertiliser or pesticides to grow. It grows faster than land plants and absorbs CO_2.

Sea Health Products has been a recent participant in the UTS Green Light Program with science mentors helping 'to optimise culture techniques for *Ecklonia radiata*."

My dream is for kelp to become a pantry staple – I want to improve the health of our oceans, the health of our planet and the health of Australians" says Jo (Look at our website – www.seahealthproducts.com.au)

Algae Biotech Accelerator gets the Green Light for Round 2

Marea Martlew, **Faculty of Science, University of Technology Sydney (UTS)**
Dr Alex Thomson, **Manager, Deep Green Biotech Hub, UTS.**

The Green Light accelerator program, the world's first algae biotech accelerator program and a key initiative of the Deep Green Biotech Hub, is now open for applications. The Green Light program is part of a partnership between the University of Technology Sydney (UTS) and the NSW Government's Boosting Business Innovation Program that helped establish the 'Deep Green Biotech Hub' (DGBH) at UTS in 2016.

Following the successful launch of the Green Light program in September 2018, NSW based small to medium sized enterprises (SMEs) and startups are being sought for the second round of the program. Successful applicants for the five-month Green Light accelerator program will have access to seed funding of up to $20,000, research expertise and mentoring, masterclasses and networking opportunities to support research and development into algae-based products and services.

The first round of Green Light, which began in 2018, saw both NSW SMEs and startups working on developing innovative microalgae and macroalgae products. By leveraging the algae biotech expertise within the UTS Climate Change Cluster, Green Light participants worked on developing innovative, impactful, algae businesses.

Climate Change Cluster DECRA Fellow Dr Manoj Kumar (L) and Sea Health Products owner Ms Jo Lane with Golden Kelp. Dr Kumar is a leading algae expert and a mentor for Green Light.

Sea Health Products, based at Tilba on the NSW South Coast, is Australia's first kelp business and was one of three successful teams accepted for Round 1 of the Green Light accelerator program.

The business, which prides itself on a sustainable low-carbon footprint model, harvests Golden Kelp (*Ecklonia radiata*) by hand from the beach and converts the seaweed into a range of kelp-based health products and foods. Now nearing the end of its intensive five-month journey with the Green Light accelerator program, business owner Jo Lane said that "**the project has really been a wonderful experience**".

For more information about the Green Light accelerator and to apply for Round 2 before the closing date in May visit https://deepgreenhub.uts.edu.au/greenlight/

To learn more about the Deep Green Biotech Hub,

Contact: Dr Alex Thomson
Manager Deep Green Biotech Hub
algaebiotech.hub@uts.edu.au
or subscribe for the newsletter at https://deepgreenhub.uts.edu.au

Student Presentation Award Winners –

32nd ASPAB Annual Meeting at SARDI. Adelaide.

Erin Cumming: 1st Prize winner

The 32nd ASPAB meeting took place at the South Australian Research and Development Institute (SARDI) from the 26th – 27th of November 2018. We awoke to a sunny Adelaide and made our way down to SARDI for day one. During the day meeting talks ranged from toxic microalgae to the indigenous uses of Australian seaweeds, highlighting the diverse pool of knowledge that the ASPAB community is made up of. We finished off the day with the conference dinner down on the strand where I was lucky enough to receive first prize for the student talks. Day two consisted of a tour of the SARDI facility where we were able to gain insight into the many different research areas working within SARDI. A personal highlight was being able to view the oyster hatchery and talk with the researchers involved in the Integrated Marine Observing System (IMOS) group. While this year's meeting was quite small compared to previous meetings it was great to converse with each researcher individually and gain insight to everyone's work. Looking forward to seeing everyone at the next meeting.

Zoë Brittain: 2nd Prize winner

I was lucky enough to attend the 32nd ASPAB meeting in Adelaide from the 26th-27th of November 2018. This was my first conference experience and it was fantastic to see the breadth of research taking place within the ASPAB community. Talks were given by both students and seasoned professionals on a diverse range of topics from toxic algae blooms, the complexities of seaweed taxonomy and developments in mariculture techniques for Australian seaweed species. Although the meeting was quite small, this made the conference dinner that much more enjoyable, as I was able to converse with most researchers on a range of topics, and where I was lucky enough to be awards 2nd prize for the student talks. I cannot wait to see what the next meeting holds!

Marine Conference/Symposium 2019

3rd Australia New Zealand Marine Biotechnology Society Conference

Marine Biotechnology Solutions For 21st Century Challenges

Venue: University of New South Wales, Sydney
Dates: Mon-Wed 20-22 May 2019
Contact: Suhelen Egan (Chair) s.egan@unsw.edu.au
Visit: https://anzmbs.asn.au/2019-conference
Registration Closes on 1 May 2019
Special Issue Submission: *Marine Drugs* and *Journal of Marine Science and Engineering (JMSE)*, Closes on 31st October 2019

The program will present the latest science and industry updates relating to Marine Biotechnology as well as covering:

- New science and technology that will underpin marine biotechnology and the blue economy
- Commercialisation of marine bioproducts and processes
- Environmental remediation and sustainability
- Influencing public perception and policy on marine biotechnology

Program will include dedicated sessions on the following topic areas:

- Fisheries and Aquaculture
- Marine Ecosystem Engineering
- Marine Environmental Health: Monitoring and Conservation
- Marine Biotechnology Policy and Consultation
- Marine Natural Products 1: Drug discovery
- Marine Natural Products 2: Algal products and biofuels

Symposium of the International Association of Cyanophyte/Cyanobacteria Research

11-16 August 2019, Moreton Bay Research Station, North Stradbroke Island (Minjerrabah), Australia

Scientific topics and themes:

- Cyanobacteria biodiversity and phylogeny
- Biotechnology
- Cryptic species
- Morphological convergence (polyphyletic genera)
- Unculturable biodiversity (including discussion on proposed candidatus concept)
- Mechanisms responsible for diversification of cyanobacteria
- Characterising cyanobacterial communities using high-throughput sequencing
- The 'omics age - new advances in cyanobacteria research - integration of metagenomics into ecological studies, monitoring studies, biodiversity studies
- Responses of cyanobacterial communities to changing environments
- Taxonomy and ecology of cyanobacteria from extreme environments
- The 'cyanosphere': interactions between cyanobacteria and associated microbes
- HGT and its implications for taxonomy and species recognition

For more details visit: https://agriculture.uq.edu.au/event/iac21

Invitation to Attend

On behalf of the local organising committee, we would like to invite you to attend AMSA 2019, a nation-wide conference that will be hosted in Perth on the 7 – 11 July at Fremantle Esplanade.

AMSA (www.amsa.asn.au) is Australia's peak professional marine science body with nearly 1000 members from around Australia. We are proud to be at the forefront of marine science in Australia, and our annual conferences allow us to showcase cutting edge research from leaders in the field while strengthening the network and collaboration between marine scientists.

The theme of AMSA 2019 is "Marine Science for a Blue Economy". The theme focuses on science that will contribute to safeguarding the health of our oceans and marine life while also sustaining the economic and societal benefits that accompany a growing nation. Invited national and international plenary speakers will impart their knowledge relating to the blue economy, and symposia topics will be inclusive of a wide range of disciplines including the critical blue economy challenges outlined in Australia's National Marine Science Plan. The theme, and the conference itself, is an exciting venture that will help facilitate and foster collaborative partnerships between industry and marine science researchers well into the future. *For more information please visit: www.amsa19.amsa.asn.au*

Our goal for Australian Society for Fisheries Biology (ASFB) 2019 is to showcase and celebrate the many ways we can illuminate the wonderful world of fishes in the hearts and minds of people spanning a range of cultures, backgrounds and perspectives. Our conference program has workshops, special events and sessions that will explore how effective communication via the visual arts, digital media, and the spoken and written word can bring new understanding and inspiration to the millions of people who value and depend on fishes for their wellbeing. A special networking event dubbed 'Big Messages for Decision Makers', will take advantage of our gathering in the national capital. Speakers will make a short pitch of their big idea for the future of fish and fisheries to key people in Government departments and agencies responsible for policy and investment in our aquatic resources.

For more information please visit: http://asfbconference.org/


33rd ASPAB Annual Meeting
Wellington, New Zealand.
November 11-13th, 2019
@ NIWA, Greta Point
More information:
www.aspab.org
Australasian Society for Phycology and Aquatic Botany (ASPAB)