Photo: Colin Lock

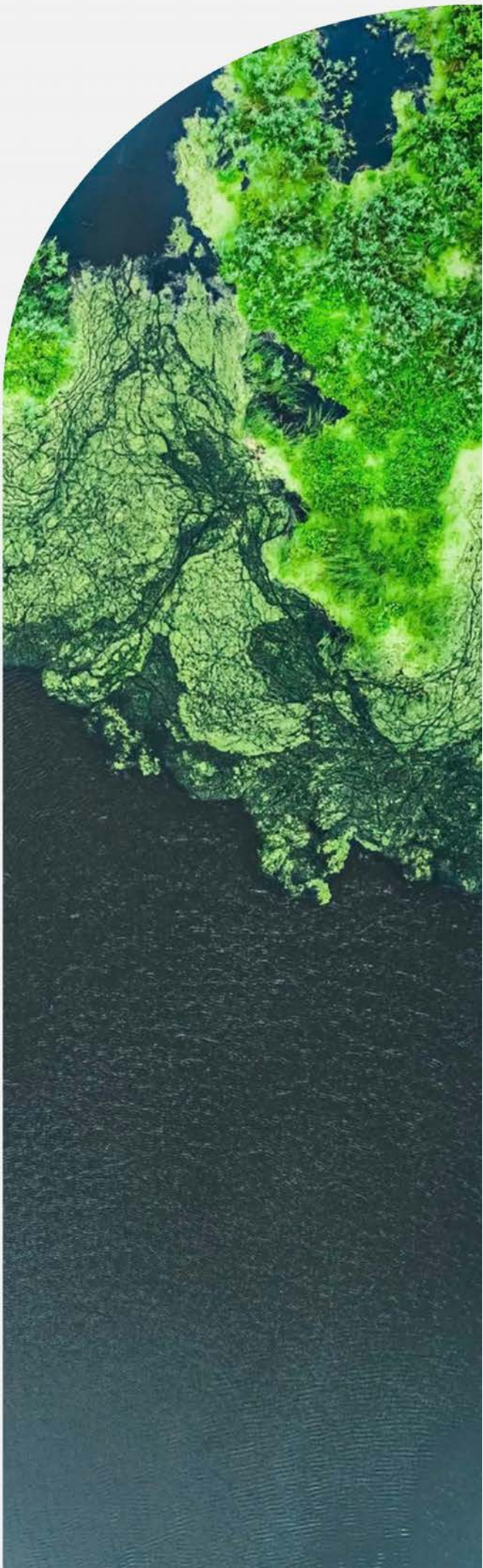
2023 ANNUAL REPORT

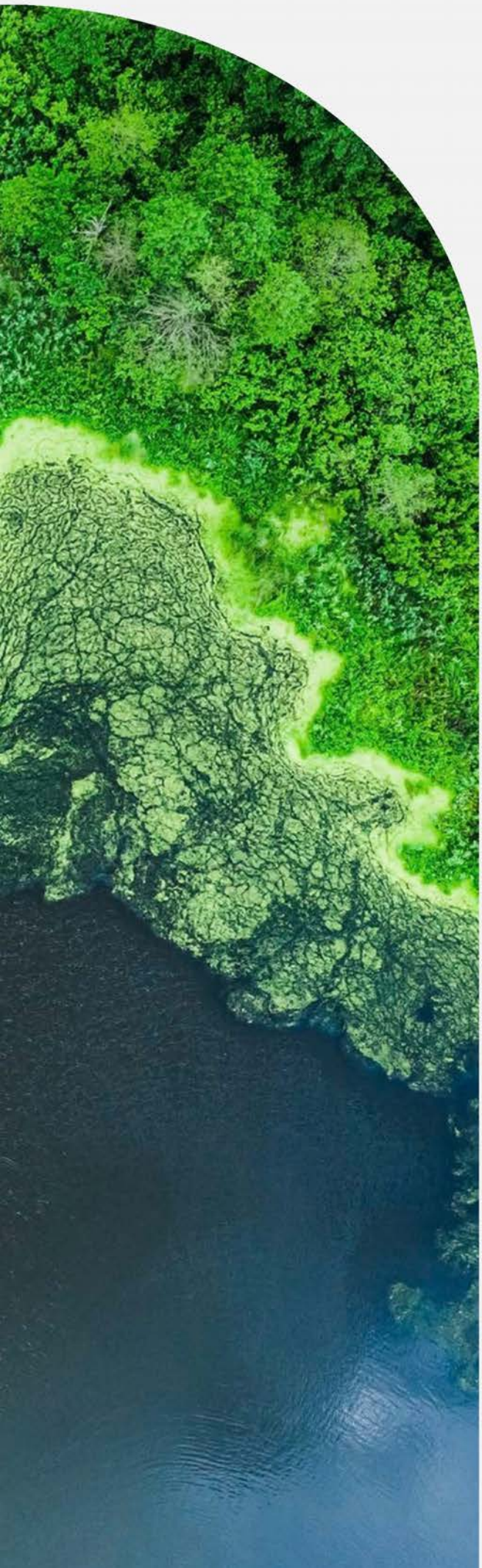
UTS Climate Change Cluster (C3)

Acknowledgement of Country

C3 acknowledges the Gadigal People of the Eora Nation, the Boorooberongal people of the Dharug Nation, the Bidiagal people and the Gamaygal people upon whose ancestral lands our university stands.

We would also like to pay respect to the Elders both past and present, acknowledging them as the traditional custodians of knowledge for these lands.





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Director's Address

As I reflect on 2023, I am immensely proud of the progress and achievements that the institute has made in terms of providing meaningful strategies for climate adaptation and innovative mitigation solutions in the Australian and global bio-economies.

Delivering greater technological and social impact has required C3 to develop our research beyond the confines of a traditional publication, often requiring a carefully integrated and collaborative multi-disciplinary team with a shared vision. Our achievements in 2023 continue to provide me with confidence that we have learned to mature our research beyond the laboratory and translate our technologies and knowledge with the support of manufacturers, community stakeholders, and users.

Highlights of these achievements include;

- Ocean Microbes Group's Eureka prize nomination for their portfolio of microbial source tracking projects, which informs on-the-ground management of failures in stormwater and sewerage infrastructure by determining the primary causes of poor water quality at Australian beaches.

- The launch of v2Food's Replihue technology that incorporates red algae co-developed with the Algal Biosystems and Biotechnology Team that mimics the experience of cooking animal-based meat by enabling the plant-based protein to change colour at the same temperature as animal meat.

- The Future Reef Team supporting the Anindilyakwa Rangers in studying corals of Groote Eylandt and contributing to their Sea Country Management plan, helping to identify areas of ecological importance to protect their reef environments.

- The Productive Coasts Team continuing to inform the National Outfall Database of the environmental concentrations and ecological significance of a range of emerging contaminants.

The impact of these projects did not happen overnight and were the result of a long history of collaboration with external partners and sustained research excellence across many years – with the individual recognition of our researchers well deserved!

I look forward eagerly to reviewing the impact of our work in 2024 and the years to come.

Prof. Peter Ralph
Executive Director,
Climate Change Cluster, UTS

About the Climate Change Cluster

Our institute specialises in research and innovation in multiple disciplines relating to marine science, ocean microbiology, productive coastlines, coral reef ecosystems, and algal biotechnology.

The Climate Change Cluster (C3) is a multidisciplinary research institute composed of over 100 research and support staff and students. C3 boasts one of the highest concentrations of interdisciplinary aquatic specialists in the Asia Pacific region, with a proven track record of high performance, industry engagement, and successful funding.

Our research generates a deeper understanding of the world's aquatic plant and microbe ecosystems, which are crucial to the well-being of the global community. Our work provides new insights that address the challenges posed by human activity and ecological interactions with the climate.

Our vision is to achieve global recognition for transforming society through scientific discovery. We offer effective strategies for climate adaptation by enhancing our understanding of climate change impacts on ecosystems and promoting climate mitigation through innovations in Australia's bioeconomy.

Our mission is to conduct high-impact, inter-disciplinary research that deepens the under-standing of climate change effects on ecosystems and society. We strive to transform society by developing strategies to tackle major global challenges, including food and energy security, sustainability, ecological resilience, and global health.

C3 Research Groups

C3 undertakes integrated and interdisciplinary research at the intersection of the physical, chemical, and life sciences. Our research is comprised of the following programs;

Algae Biosystems and Biotechnology

The climate emergency has inspired us to develop innovative biotechnology to **decarbonise manufacturing** and establish **sustainable bioeconomies.** Our research addresses the biggest environmental and societal issues facing Australia and other countries in a changing climate, including food and energy security, sustainability, ecological resilience, and global health.

The key to our research is the incorporation of algae – both seaweeds and microalgae - in innovative **green and clean technologies.** C3 is one of the world's largest groups of integrated algae specialists, harnessing the power of algae together with robotics and artificial intelligence to decarbonise key manufacturing and utility sectors of the economy and hasten the global move away from fossil fuels as an energy and raw materials source.

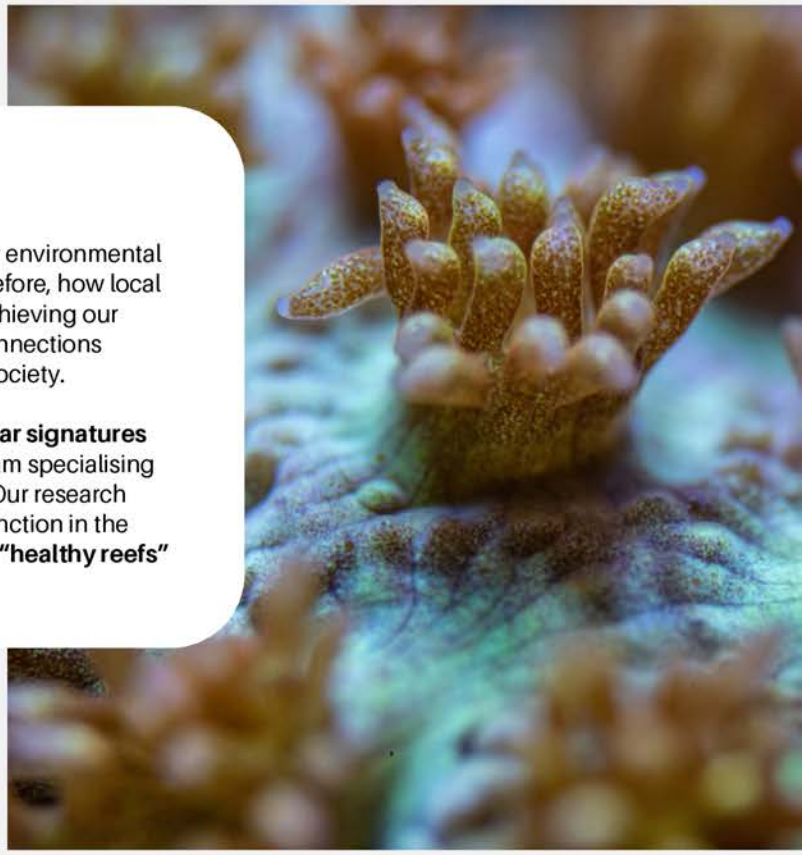
Productive Coasts

With continued increases in surface temperatures and ocean acidification, organisms inhabiting the ocean are living in an increasingly unpredictable world; influencing the **health of marine organisms, water quality and sediment quality.** The Productive Coasts team's research focuses on examining processes that impact water and sediment quality so that we can **inform policy, investment and regulation** to deliver sustainable solutions to the global challenges of climate change and coastal development. Our research is conducted in partnership with the government (international, national, state, and local), industry (including water authorities), and indigenous communities.

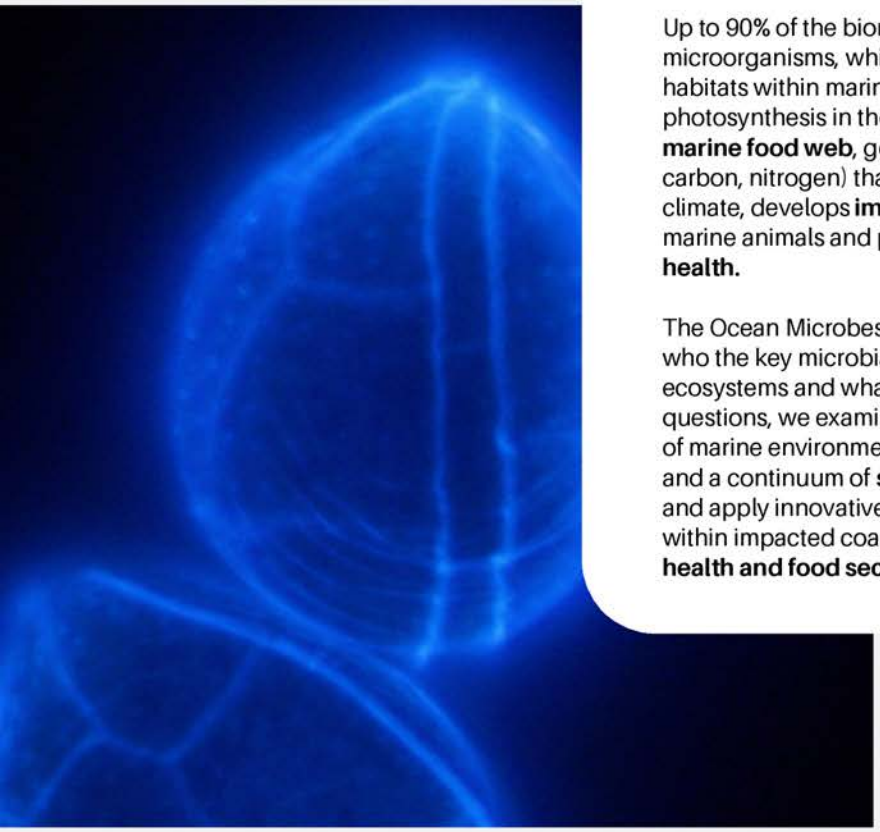
Future Reefs

The Future Reefs Teams' goal is to understand how environmental conditions influence the coral 'holobiont' and, therefore, how local stressors and climate change impact coral reefs. Achieving our mission of sustainable change requires genuine connections across all levels of industry, government, and civil society.

Our research ranges from **organism-scale molecular signatures** to **broad-scale ecological interaction**, with our team specialising in advancing technical solutions to meet our goal. Our research outcomes directly inform how reefs will look and function in the future, but also how to better preserve and re-build **"healthy reefs"** of tomorrow.



Ocean Microbes



Up to 90% of the biomass in the ocean is made up of microorganisms, which play critical ecological roles within all habitats within marine ecosystems. They perform the majority of photosynthesis in the ocean, which supports the **base of the marine food web**, governs **important chemical cycles** (e.g. carbon, nitrogen) that mediate ocean productivity and global climate, develops **important ecological interactions** with marine animals and plants, and can even **impact human health.**

The Ocean Microbes Group tackles the important questions of who the key microbial populations are in different ocean ecosystems and what they are doing. To answer these questions, we examine the ecology of microbes across a range of marine environments (from tropical coral reefs to Antarctica) and a continuum of **spatiotemporal scales**. We also develop and apply innovative approaches for measuring water quality within impacted coastal ecosystems to safeguard **human health and food security.**

Awards and Achievements

Celebrating a selection of awards and achievements from the C3 team

2023 Australian Museum Eureka Prizes
Professor Justin Seymour, Dr Nahshon Siboni, and Dr Nathan Williams were finalists for the 2023 NSW Environment and Heritage Eureka Prize for Applied Environmental Research for their work with Central Coast Council and the NSW Department of Planning and the Environment on protecting water quality at Australian beaches

Women of Discovery Award - WINGS World Quest
Dr Emma Camp was awarded the WINGS Women of Discovery Annual Award, which celebrates and showcases the ground-breaking expeditions of women scientists and explorers whose discoveries advance scientific inquiry, stimulate conservation, and lead to a better understanding of our world.

V2food Takes Alt-meat Mainstream with C3-invented Algae-Derived Pigments.
v2food unveiled its new colour system for plant-based meats at Sydney's South by Southwest (SXSW). The technology, which was co-invented and developed with CSIRO, C3, and Lgem, incorporates a red algae that changes colour through the cooking process - "mimicking" animal meat and creating the "next generation" of 'bleeding' plant-based proteins. Retail distribution is anticipated to commence in 2024.

NSW Young Tall Poppy Science Award
Dr Jen Matthews was awarded The Young Tall Poppy Science Award, an initiative of the Australian Institute of Policy and Science. The award aims to recognise excellence in research as well as enthusiasm for communicating science beyond the walls of the laboratory.

Research Fellowships
Dr Ariel Pezner: UTS Chancellors Postdoctoral Research Fellowship

- Dr Pezner will be joining the Future Reefs Team to work on drivers of low oxygen tolerance in extreme reed habitats over space and time.

Dr Elliot Scanes: ARC DECRA

- Dr Scanes will continue his work within the Ocean Microbes Group on protecting oyster aquaculture from heatwaves and flooding rains.

Photo: Colin Lock

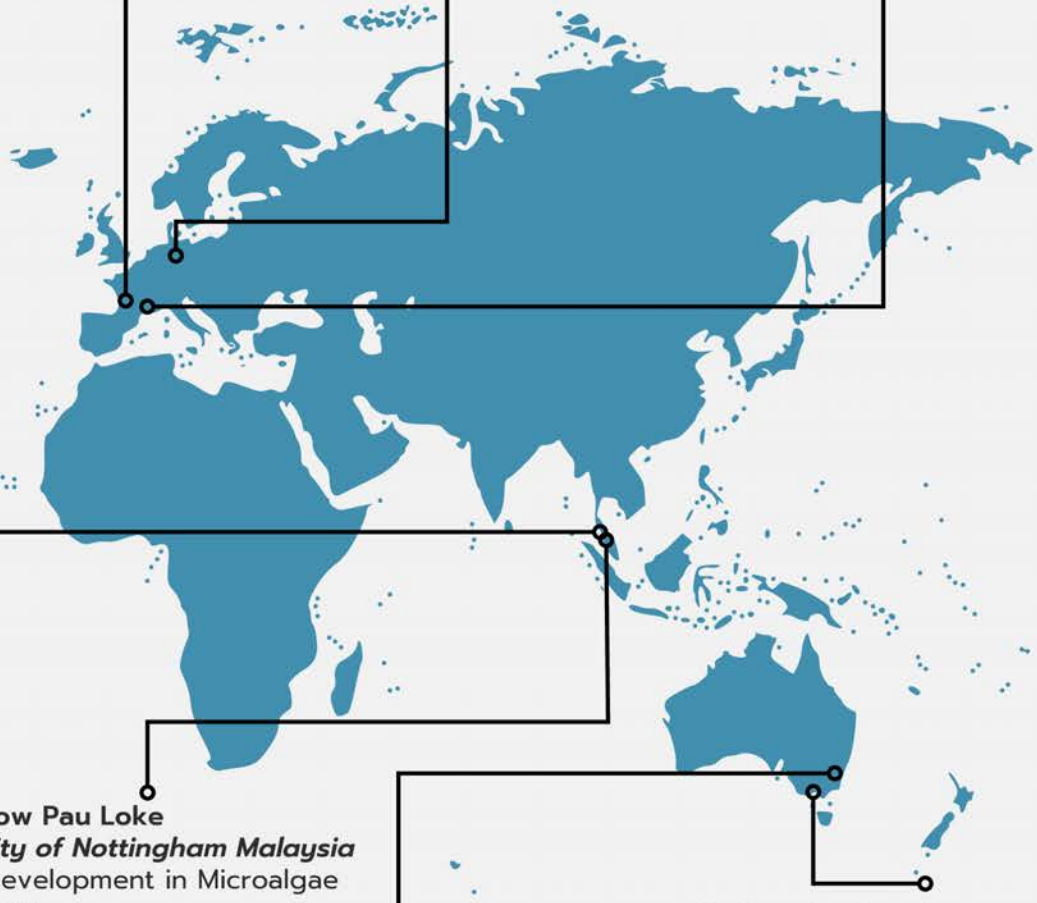
Photo: John Edmondson

C3 Seminar Series

Dr Manuel Rodrigo Rangel
Fermentalg
High-throughput Applications in Microalgal Biotechnology

Dr Mridul Thomas
University of Geneva
Getting to the Heart of How Interacting Environmental Drivers Shape Ecological Dynamics

Dr Thomas Wichard
Friedrich Schiller University
The Green Macroalga Ulva - A Model System in Chemical Ecology and its Potential Applications in Aquaculture



Prof. Show Pau Loke
University of Nottingham Malaysia
Latest Development in Microalgae Biorefinery

Prof. Adibi Nor
University of Malaya
Seaweed Cultivation: A Nature-based Solution to Climate Change and Food Insecurity

Dr Douglas Brumley
University of Melbourne
The Role of Fluid Dynamics in Microbial Ecology

Prof. Sandra Kentish
University of Melbourne
Capture and Utilization of Carbon Dioxide in Algal Cultures

Dr Pearse Buchanan
CSIRO
Enrichment of Ammonium in a Future Ocean Threatens Diatom Productivity

Dr Wing Chan
University of Melbourne
Enhancing Coral Thermotolerance via Symbiont Bio-engineering

Team Leaders

Director
Peter Ralph

Team Leader
Productive Coasts
Martina Doblin

Team Leader
Future Reefs
Emma Camp

Deputy Director
Mathieu Pernice

Team Leader
Ocean Microbiology
Justin Seymour

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Senior Research Fellow
Jean-Baptiste Raina
Unnikrishnan Kuzhiumparambil

Chancellor's Postdoctoral Research Fellow
Elliot Scanes
Jennifer Matthews
Phong Vo

Postdoctoral Research Fellow
Andrei Herdean
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Nahshon Siboni
Nature Poddar
Vishal Gupta

Postdoctoral Research Associate
Amaranta Focardi
Charlene Trestrail
Lorna Howlett
Maeva Brunet
Paige Strudwick
Sana Malik
Stalin Kondaveeti
Wyatt Million

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Abeeha Khalil
Alexandra Skeer
Amanda Grima
Amber Brierley
Anna Caterina Pozzer
Axel Olander
Bhuwan Ghimire
Caitlin Younis
Chantal Philippe
Christine Roper
Farjana Akter
Gemma Gilette
Giselle Firme
Hadley England
Kira Picknell
Laura La Motta
Lilian Hoch
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Emma Earley

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Cora Hinkley
Fateme Mirakhorli
Kia Billings
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Lorenzo Paolieri
Mark Brown
Mark Liu
Martin Ostrowski
Mikael Kim
Nandhini Ravi
Nathan Williams
Paris Hanan
Raissa Gill
Robert Rodger
Taisiia (Taya) Lapshina

Assistant Technical Officer
Abeeha Khalil
Allen Lo
Anjon Mondal
Anna Tevaga
Breanna Osborne
Fiona Shadwick
Hadley England
Isaac McElhinney
Laura Korn
Lucia Bennar
Massimo (Mass) Bedoya
Melyssa van der Splinter
Natalie (Lji) Radojcic
Taine Leyshon
Thai Bach (Eric) Luong

Taking a Bite Out of Carbon Emissions

A research partnership between C3 and v2food is exploring ways that algae can transform the way we eat - and provide solutions to the climate crisis.

Not only are microalgae carbon capturing superheros – sucking up carbon dioxide 40 times more efficiently than trees – the photosynthetic organisms are also growing in popularity as a key in-gredient in the plant-based food movement.

C3 and v2food, a leading plant-based meat company, are collaborating on a novel research project to explore incorporating algae into meat-alternative food products, co-designing a novel algal-derived pigment that can change colour when it is cooked in the same way and at the same time as meat.

The partnership draws together C3's considerable expertise in algae biotechnology with v2food's passion for transforming the way we eat.

"Food systems are responsible for more than a third of the world's green-house gas emissions, with meat and dairy contributing nearly 15 per cent of global totals" says C3 Director Professor Peter Ralph.

"Shifting humans to a plant-based diet has the potential to deliver significant positive impacts to the health of the planet."

Selected by CSIRO as one of 10 Australian deep-tech innovators for the 2023 ON Accelerate program, the partnership aims to address climate change by promoting sustainable food choices.

Coral Boost with Funding Injection

C3 Researchers Win $2.1 Million Grant to Enhance Coral Resilience

Researchers from the University of Technology Sydney have secured a $2.1 million grant from the 2022 Coral Research and Development Accelerator Platform (CORDAP) to enhance coral resilience through nutritional supplements. The project is led by Dr. Emma Camp, with Distinguished Professor Philip Doble and Dr. Jennifer Matthews.

The UTS team will collaborate with Monsoon Aquatics, Australia's largest aquaculture facility, and university partners in Malaysia, Indonesia, and Monaco. Dr. Emma Camp, Team Leader of the Future Reefs Program at C3, and the team are developing a coral nutritional supplement called 'CoraBoost' to improve the resilience of tropical and cold-water corals during restoration and heat stress periods.

"Corals, like humans, need balanced vitamins and mineral levels to thrive, particularly when they're under stress. Because corals are typically found in low nutrient waters, 'CoraBoost' will help improve the health of reefs by improving the quality and quantity of nutrients in their habitats" explained Dr. Camp.

CORDAP, a G20 initiative, is dedicated to fast-tracking research and development solutions to save the world's corals. With two-thirds of the world's coral reefs already lost due to human activity and 70-90% of the remaining reefs at risk of disappearing in the next 10-15 years, urgent action is needed. One in four marine species depend on coral reefs, and they provide food, income and coastal protection for one billion people. The estimated global economic value of coral reefs is nearly US$10 trillion per year through ecosystem services and goods.

Number Two Solution

C3 scientists have teamed up with the government to pinpoint the sources of sewage pollution on a popular NSW beach.

While most Australian beaches have good water quality, it can deteriorate quickly after heavy rain, making beach days less enjoyable. Identifying the exact sources of contamination can be challenging. "The water quality testing routinely conducted at beaches is great at detecting faecal contamination, ensuring they can stay open safely," says Professor Justin Seymour, Team Leader for the Ocean Microbes Group at C3. "But it lacks the precision to identify whether the exact source is human sewage, domestic animals, farm animals or wildlife, which is an important question to answer if you want to fix the cause of contamination."

Terrigal Beach on the Central Coast has faced poor water quality for a decade, consistently rated "poor" by the NSW Government's Beachwatch monitoring program. Central Coast Council collaborated with UTS and the NSW Department of Planning and Environment to investigate the issue. "Using a suite of cutting-edge tools to track microbes and analyse their DNA we were able to show the dominant source of contamination was human sewage with a minor contribution from dog faeces in the surrounding catchment" Professor Seymour says.

"We found that sewage overflow into a specific storm water drain was the primary factor affecting water quality."

This discovery enabled the council to focus on sewer remediation. "We inspected 115km of sewer mains and identified one third of these as in need of repair. We've since remediated 41km, which is 95 percent of this problem sewerage infrastructure" says Jamie Loader, Director of Central Coast Council Water and Sewer.

Professor Seymour and his team are not stopping there. They aim to further refine their toolkit for the Australian environment, making it quicker and easier to use. "We're looking at identifying various microbes and markers that are specific to Australian environment – such as bacteria found in native animal and bird faeces. The team is looking to import the identification technology into a mobile laboratory, so scientists and researchers can analyse the microbial source of contamination in a more timely and efficient manner in the future" explains Professor Seymour.

Office Air Conditioners Can Reduce the Risk of Harm from Bushfire Smoke

Air conditioning doesn't just cool the air - it can also reduce the risk of harm from bushfire smoke, new research suggests.

Air conditioning in workplaces not only cools the air but also helps trap particles from bushfire smoke, reducing exposure to harmful elements like soluble mercury, sulfate, and nitrate, according to new research. Bushfire smoke can exacerbate health conditions such as asthma, COPD, and heart disease, increasing the risk of hospitalization and death.

The study, recently published in the journal Environmental Pollution, was led by C3 UTS PhD candidate in environmental science, Raissa Gill, a recipient of a UTS Research Excellence Scholarship, together with researchers from UTS and UNSW Sydney.

"The bushfires that raged across Australia during the 2019-2020 'Black Summer' produced an enormous amount of air pollution, with plumes of smoke travelling long distances and cloaking Sydney and surrounding areas," said Gill.

"By using commercial air conditioning filters, we were able to capture and analyse the chemical composition of particles that would otherwise have been inhaled."

Researchers collected particulate matter from HVAC filters in UTS Buildings 4 and 7 during the peak of the fires and a year later as a reference.

They found that daily particulate matter concentrations were 2-3 times higher than normal, and hourly concentrations reached up to 10.5 times the usual maximum. This exceeded the national standards on 19% of days across the four-month sampling window. The particles were also finer and contained a different mixture of toxic chemicals.

"Bushfire aerosols contained much smaller, rounder particles than urban aerosols, making them more likely to be inhaled into our lungs and to transfer toxic elements into our blood stream," said co-author UTS Professor Martina Doblin.

The study underscores the importance of using higher-rated HVAC filters during fire seasons and maintaining them regularly. "Australians face significant obstacles in achieving satisfactory air quality during major bushfire events. Many homes and older buildings rely on natural ventilation or have poor HVAC filtration efficiency and gaps that allow smoke to enter.

"Given that severe bushfires are projected to increase with climate change, the role of bushfire-ready infrastructure in maintaining public health, as well as the need to reduce greenhouse gas emissions, is now more pressing than ever," Gill said.

Photo: Andy Roberts

Key Publications

Molecular insights into the Darwin paradox of coral reefs from the sea anemone Aiptasia
Guoxin Cui et al., 2023
Science Advances

Chemotaxis increases metabolic exchanges between marine picophytoplankton and heterotrophic bacteria
Jean-Baptiste Raina et al., 2023
Nature Microbiology

The role and risks of selective adaptation in extreme coral habitats
Federica Scucchia et al., 2023
Nature Communications

Save the planet with green industries using algae
Peter J. Ralph, Mathieu Pernice, 2023
PLOS Biology

Coral endosymbiont growth is enhanced by metabolic interactions with bacteria
Jennifer L. Matthews et al., 2023
Nature Communications

Biomining for sustainable recovery of rare earth elements from mining waste: A comprehensive review
Phong H N Vo et al., 2023
The Science of The Total Environment

Contrasting phytoplankton composition and primary productivity in multiple mesoscale eddies along the East Australian coast
Giselle F. Firme et al., 2023
Deep Sea Research Part I Oceanographic Research Papers

Strong chemotaxis by marine bacteria towards polysaccharides is enhanced by the abundant organosulfur compound DMSP
Estelle E. Clerc et al., 2023
Nature Communications

Partnerships

YOUNG HENRYS

PIPING HOT FOR CLEAN OCEANS

v2 food

mla MEAT & LIVESTOCK AUSTRALIA

CORAL NURTURE PROGRAM

Australian Government
Great Barrier Reef Marine Park Authority

UNITED NATIONS DECADE ON ECOSYSTEM RESTORATION 2021-2030

GORDON AND BETTY MOORE FOUNDATION

Inspiring AUSTRALIA

Central Coast Council

marine bioproducts cooperative research centre

NSW GOVERNMENT | Planning and Environment

National Environmental Science Programme

Julius Bär FOUNDATION

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