Cyber-Marine

Newsletter 4 | February 2024

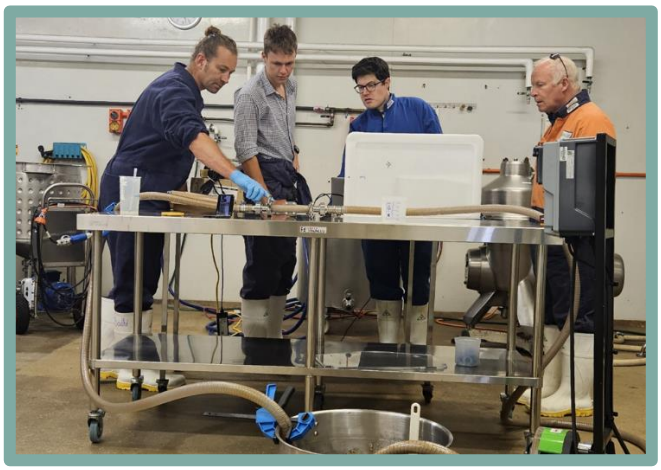
Welcome to Cyber-Marine newsletter number 4. We're now nearly 3.5 years into the programme and our research is getting more focused on the end goal of a multi-product processing plant that can make optimal use of New Zealand's marine raw materials.

Research update

What's in there? Our mammoth sampling effort on the test species (hoki, mackerel and Greenshell™ mussel) is now complete. Thanks to all of you who went out of your way to provide such high-quality tissue (Sealord, Talley's, MacLab, Pelco, Aroma). Final wet chemistry and laser spectroscopy analyses are underway at Plant & Food Research, Callaghan Innovation and University of Otago, and are delivering the last datapoints for development of the rapid compositional analysis model at Victoria University of Wellington.

However, as everyone is rather quick to point out, a factory is quite a different environment to our labs. This summer, supervised by Dr David Aitchison at Trinder Engineering, Fergus Monk, an engineering student from the University of Canterbury, has been working on an inspection window that fits into industrial piping and allows in-line laser spectroscopy in the Plant & Food Research pilot plant. Since the start of Cyber-Marine in 2020, there have been rapid advances in miniaturised diode lasers and detector technology, meaning that we now have relatively inexpensive and effective instruments that can be attached to the inspection window and are able to gather data.

Trials with hoki by-products (from Talley's rendering plant) were carried out and a comparative analysis is underway to see how well the pilot system performed at predicting composition relative to wet chemistry. We are well on the way to being able to make choices about processing a raw material in real time, based on the composition.



Testing the Raman/NIR flow cell at the Plant & Food Research pilot plant in Nelson. L to R: Bodhi Bettjeman (Plant & Food Research), Fergus Monk (Trinder Engineering), Jeremy Rooney (University of Otago) and David Aitchison (Trinder Engineering).

How do we get the molecules out? We have developed a range of approaches for getting the molecules out of the raw material. We have focused particularly on the lipids and the proteins, and ways to recover both whilst retaining their quality and functional properties. In addition to the functional proteins such as enzymes and collagen that are definite Cyber-Marine targets, 'food' protein is getting increasing emphasis due to a predicted global dietary deficit. We are looking at whether by-products can deliver an economic source of high-quality edible protein as part of the multi-product cascades.

Getting the phospholipids out is very challenging and has required development of supercritical processes. However, many of the other extractions, although requiring good control of pH and temperature, utilise standard equipment such as centrifuges, membrane systems and driers. We have tested processes at scale at the Food Bowl, the Plant & Food Research pilot plant and again at Talley's rendering plant (many thanks to Ray Forscutt and his team). We are currently designing a range of processing cascades that require different equipment and deliver different products to suit the processing needs of different companies. The next year will see testing of full cascades through to products, including understanding of yield and throughput, and some preliminary technoeconomic modelling.

What's new? The extracts from our cascades are products in their own right; however, in the third part of Cyber-Marine we're also investigating what novel products can be made from these extracts. At Deakin University, the team is working on synthesis of glycolipids, attaching carbohydrates to marine-sourced fatty acids. These compounds have potential as anti-inflammatories and antimicrobials, but also as new food-grade surfactants and emulsifiers.

Recognition for Cyber-Marine researchers

Dr Kirill Lagutin (Callaghan Innovation) received a **Science New Zealand 2023 Award** as an **Early Career Researcher.** Recipients of this award have made an outstanding contribution to the values and purpose of their institutes through research and engagement with colleagues, partners, and the wider community – nationally or globally. Awards 2023 » Science New Zealand

Kirill talks about his work here:
https://vimeo.com/887784706/63c4035514?share=copy

Kirill Lagutin (centre) receiving an Early Career Research Award.

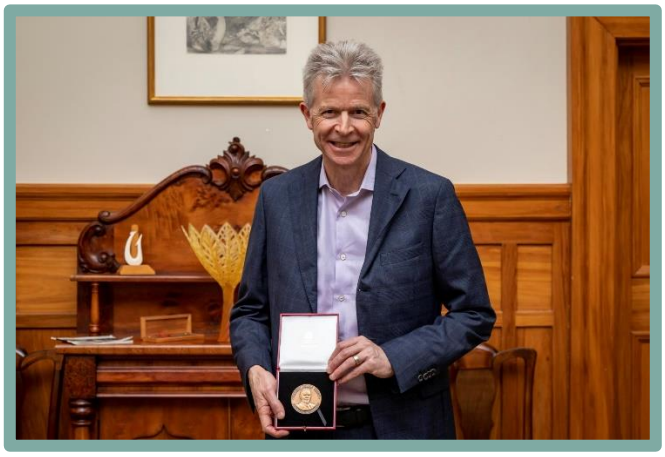
Professor Mengjie Zhang and **Professor Bing Xue** (Victoria University of Wellington) were each recognised as **Clarivate Highly Cited Researchers 2023** for their significant and broad influence in the field of Computer Science. To be selected you must have authored multiple highly cited papers over the past decade.

Mengjie Zhang - Web of Science Core Collection and Bing XUE - Web of Science Core Collection

Professor Mengjie Zhang

Professor Bing Xue

Dr Owen Catchpole (Callaghan Innovation) has been awarded the **2023 R J Scott Medal** by Royal Society Te Apārangi for being a world leader in the development of processes to extract high-value bioactive chemicals from biological materials using 'supercritical' solvents. The Scott Medal recognises outstanding contributions towards the advancement of engineering sciences and technologies. 2023 Scott Medal: Extracting high-value bioactives for health and wellness products (royalsociety.org.nz)

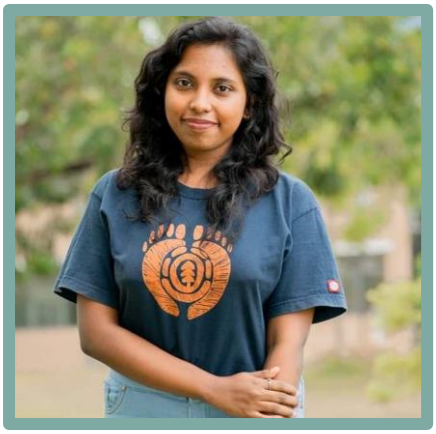


Owen Catchpole with the 2023 R J Scott medal.

New to the Cyber-Marine team

We warmly welcome our new team members:

Christina Hamit is a PhD student at **Massey University** and **Callaghan Innovation**, who started her PhD in July 2023. She is based in Lower Hutt at the Callaghan Innovation laboratories and will be studying the combined enzymatic hydrolysis and membrane fractionation of marine biomass with the aim of developing a predictive model for processing outcomes based on the types of protein present in the feed biomasses.

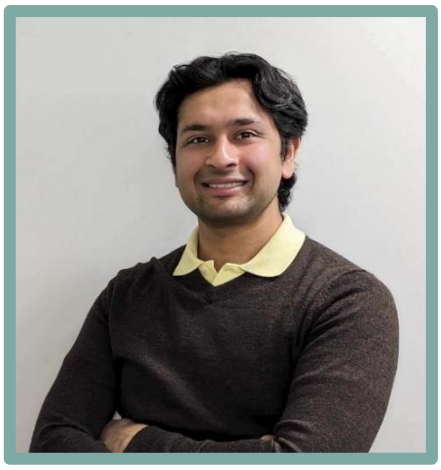


Christina Hamit

Egan Doeven is a postdoctoral researcher at **Deakin University**, in Geelong, Australia. Egan works in Professor Colin Barrow's group, the Centre for Chemistry and Biotechnology, researching the enzymatic synthesis of novel glycolipid products. Using immobilised lipase catalysts the team is combining simple sugars with a range of fatty acids, targeting the scalable production of a range of omega-3 and omega-6 based glycolipids. These novel compounds will be assessed for a range of activities, including antioxidant and surfactant properties. The project has successfully developed a flow chemistry synthesis approach, with production of a range of known and novel glycolipids, with the focus now on increasing throughput to gram scale and product characterisation and testing.

Egan Doeven

Amer Hussain started a master's thesis programme in Feb 2023 at **Victoria University of Wellington**. His work focuses mainly on using genetic programming as a machine learning method to analyse the important features and construct regression models in predicting chemical composition.



Amer Hussain

Yun Zhou started a PhD at **Victoria University of Wellington** in Nov 2023. His work will build machine learning systems to determine how well chemical composition can be predicted using vibrational spectroscopy. A key research question is whether predictions are significantly improved if multiple spectroscopy techniques are combined, compared with using each technique independently.

Yun Zhou

Kerin Thompson is the new Research Programme Co-ordinator for Cyber-Marine. Kerin is based at **Plant & Food Research** in Nelson and is your primary contact for administrative aspects of the programme. You can contact Kerin at kerin.thompson@plantandfood.co.nz

Kerin Thompson

Cyber-Marine Industry Forum – Save the Date!

This year's Cyber-Marine Industry Forum will be held from 9am-12:30pm on **Friday 12 April 2024**, at Plant & Food Research, Nelson Research Centre, 293 Akersten St, Nelson. There will also be an opportunity to visit the Cyber-Marine pilot plant in Stoke after the Forum. The Forum agenda is currently being finalised and you will soon receive more details about this exciting event. The Cyber-Marine Industry Forum coincides with the Blue Economy Innovation Summit co-hosted by the Nelson Regional Development Agency and Moananui, to be held in Nelson on 11 April.

Cyber-Marine out in the world

The Cyber-Marine Team has been out and about presenting their work at conferences in New Zealand and Australia.

NZ Institute of Food Science and Technology Conference, Dunedin, 3–5 Jul 2023

Morel J, Catchpole O, MacKenzie A and Lagutin K. *Gas-expanded liquids - a tuneable, scalable green solvent.*

Queenstown Research Week, Queenstown, 27 Aug – 01 Sep 2023

Killeen D and Marshall S. (2023) *Real-time composition of wet marine biomass: Towards industry 4.0.*

The 13th Asia Pacific Biotechnology Conference, Adelaide, 2–6 Oct 2023

Cumming M **Keynote presentation** *Research to high-tech marine collagen product.*

Sun C, Hubl U and Doorman J. **Poster Presentation** *Activity screening of glycoenzymes in fish organs from mackerel.*

Susan Marshall **Invited Panel member** for the Asia Pacific Biotechnology conference Students & Early Career Researchers Forum.

AAOCS 'The Future of Lipids' Conference, Newcastle, 13–15 Nov 2023

MacKenzie A, Scott D, Gu C, Nalder T and Bettjeman B. *Minimising the hydrolytic degradation of green lipped mussel phospholipids.*

Mitchell K, Lagutin K, MacKenzie A, Scott D, Vyssotski M, Bloor S, Killeen D and Mohammad Y. *Analytical supercritical fluid chromatography – mass spectrometry for lipid analysis – an overview and examples from our lab.*

Recent publications and conference presentations

Topal T, Card A, Mackenzie A, Lagutin K, Marshall SN, Cumming AH, Killeen DP. *Hydrophobic natural deep eutectic solvents for marine lipid extraction.* **J Am Oil Chem Soc**. 2023;1–7. https://doi.org/10.1002/aocs.12757

All marine biomass is rich in omega-3 rich phospholipids, but extracting these compounds at scale is challenging. This paper investigated whether a new class of environmentally friendly solvents 'Type V Natural Deep Eutectic Solvents (TV NADES)" could extract these media from some of NZ's most abundant marine bioresources: hoki, mackerel and Greenshell mussel. Chemical analyses of these extracts suggested total recovery of neutral lipids was possible, but that TV NADES did not extract phospholipid in high yield.

Morel J, Catchpole O, Moreno T, Lagutin K, MacKenzie A, Fenton T and Williams A. *Extraction of neutral lipids and phospholipids from marine biomasses using subcritical and supercritical fluids*. **J Supercrit Fluids** 2024; 206: 106160 https://doi.org/10.1016/j.supflu.2023.106160

In this work, lipids were extracted from marine biomasses (whole jack mackerel, hoki fins and heads, Greenshell mussel meat) using supercritical CO_2 ($scCO_2$) and subcritical dimethylether (DME). Supercritical CO_2 gave lower lipid extraction rates and yields than subcritical DME. Supercritical CO_2 gave higher lipid recoveries from finfish compared with Greenshell mussel meat, as Greenshell mussel meat contains high levels of phospholipids, which cannot be extracted by $scCO_2$, but can be extracted by DME.

The results suggested that phospholipid extraction yield can be optimised by partly drying biomass to 30–50% moisture prior to extraction. DME extracts contained good levels of omega-3 fatty acids, and high levels of phospholipid with minimal hydrolytic degradation. This study demonstrates that products of the fish processing and aquaculture industries can be used to obtain extracts that can then be used to obtain valuable supplements in the health industry, providing commercial benefits.

If you missed previous Cyber-Marine newsletters, you can access them here: Cyber-Marine · Plant & Food Research (plantandfood.com)

If you have any feedback or would like to talk more about Cyber-Marine, please contact Sue Marshall: susan.marshall@plantandfood.co.nz