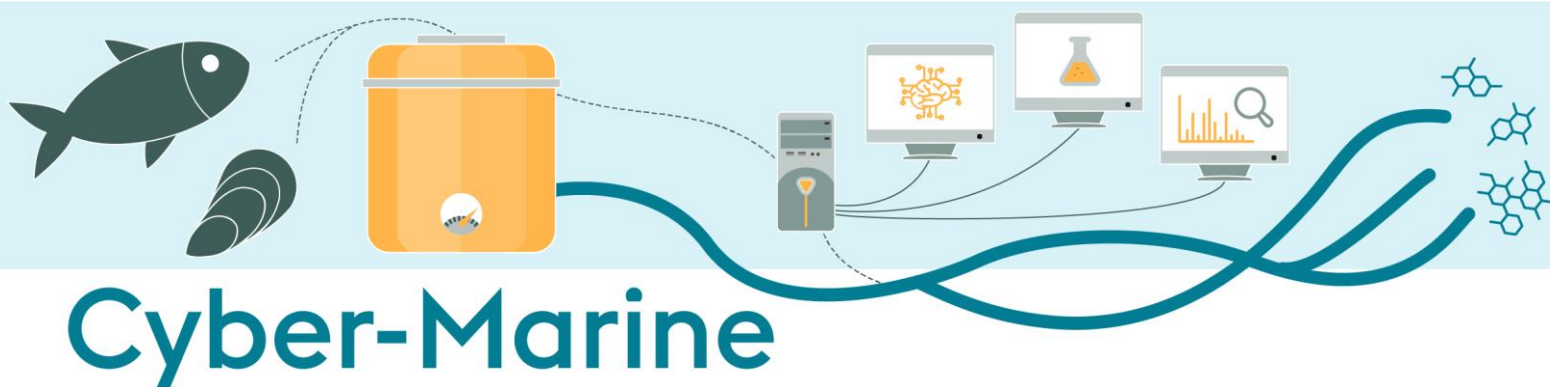




Newsletter Number 6 October 2025

After 5 years, Cyber-Marine has come to an end and Newsletter 6 will be our last. Hopefully we've convinced you of the opportunities for New Zealand from non-food marine biomass and the words 'fish waste' have been removed from everyone's vocabulary. We are immensely grateful to MBIE for funding this journey and also want to say a huge thanks to all of you: our research institutes and universities, including all the unsung support staff who helped us through; the experts in our Science Excellence Advisory Group; the seafood and marine products industry who have shown amazing generosity with raw materials, people and factory time; and our families who have put up with long hours and some very smelly clothes!

We have achieved much of what we set out to do and now things are moving on to application and commercialisation. If you want to know more about our research and how you might use it, please contact Mark Jarvis at the Plant & Food Research Group in the new Bioeconomy Science Institute (PFR BSI) and he will put you in contact with the right people

Mark.jarvis@plantandfood.co.nz

We have just submitted our final report to MBIE. Here is an excerpt:

Research Update

C-M is a collaboration between Plant & Food Research (PFR) (now part of the new Bioeconomy Science Institute), Callaghan Innovation (CI), universities (University of Otago (UoO), Victoria University of Wellington (VUW), Deakin University in Australia) and our numerous industry partners. Together we are building a future for seafood, focusing on new automated and integrated technologies and the people to run it. Since 2020 we have supported eight PhD students (including one Māori student in computer science who is about to submit his thesis), one MSc, three post-doctoral fellows, hosted a Royal Society Teacher Fellow, and five summer undergraduates. We've also worked closely with staff from companies in their factories and our pilot plants. By listening to our partners and integrating chemistry, engineering and computer science we have developed rapid analysis, low-impact technologies for efficient processing cascades, novel products, a flexible approach that provides resilience in the face of climate change (i.e. pressure on energy-use and emissions; changes in species mix, size, composition and fish health), and a path to future-automation.

Over the past 5 years our researchers, students and industry partners have worked together on new approaches to analysing and extracting marine molecules, delivering efficient low-impact processes and novel high-value products. The hypothesis underlying 'Cyber-physical seafood systems' (Cyber-Marine) is that by understanding what molecules are coming into a factory in real time, we can use AI to direct sequential extraction procedures, tailored to specific composition, as fish arrive for processing. This has required development of new analytical approaches suitable for in-factory use, AI/machine learning to interpret the data and deliver compositional information in real time, new processing technology with new ways to put unit operations together into multi-product cascades, and new insights into novel uses of the molecules to optimise value.

Highlights from this year include:

What's in there?

Our partners are interested in both on-boat and in-factory compositional analysis to allow selective harvesting and optimal process decision-making. Our extensive chemical datasets have been used to calibrate newly released portable spectroscopic

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instruments (UoO) then linked to AI-powered rapid prediction (VUW) of fish and shellfish chemistry. The Mark II prototype inspection window has been designed and built by engineering student Louis Rowell-Williams (summer intern from University of Canterbury), supervised by David Aitchison at Trinder Engineering, and inserted into the pipework in the PFR Nelson pilot plant. Together we have demonstrated the speed and accuracy of the approach in a real-world setting using hoki and Greenshell™ mussel (GSM) as the feed materials.



Louis Rowell-Williams (summer intern from the University of Canterbury) holding the spectroscopy inspection window that was used in application testing with Greenshell™ mussel slurry in the BSI Nelson pilot plant.

A cascade of products with no left-overs

Multi-product cascades have been developed for our exemplar species (hoki, mackerel, GSM) and processes tested at scale in the PFR and CI pilot plants, and at the FoodBowl. All samples have been analysed for chemical composition by spectroscopy and traditional wet chemistry, along with functionality and bioactivity to boost market development. Further testing has been carried out in partner factories. The fish cascade has been tested on two 'unknowns' at scale (tuna heads and salmon viscera), demonstrating that the approach is sound (but that some optimisation is required for different species). Engineering solutions are now under

investigation to allow in-factory prototyping with application in both New Zealand and the Pacific.

Thumbs up from industry

We have consulted with industry partners throughout the programme to understand what they want and need from Cyber-Marine. We are receiving a hugely positive response as we present product/process developments as multi-option pathways for each raw material. Each option includes yield data at every processing step and detailed product datasheets containing chemical, functional, and bioactivity information. Companies can select pathways based on their specific equipment, staffing, raw materials, product goals, and market needs—with all the information necessary to evaluate the business case.



Bodhi Bettjeman (BSI) flaking tuna heads prior to use in the Cyber-Marine fish processing cascade.

Dimethyl ether (DME): A green solvent for lipid extraction

DME is a cornerstone lipid extraction technology used in Cyber-Marine but there are technical and regulatory challenges for implementation. CI has invested in demonstration-scale equipment to make it less risky for industry. A marine products Risk Management Plan has been submitted to the Ministry for Primary Industries to enable food-grade production of high-value extracts from marine biomass. In parallel, we are supporting international collaborators in South Korea to gain

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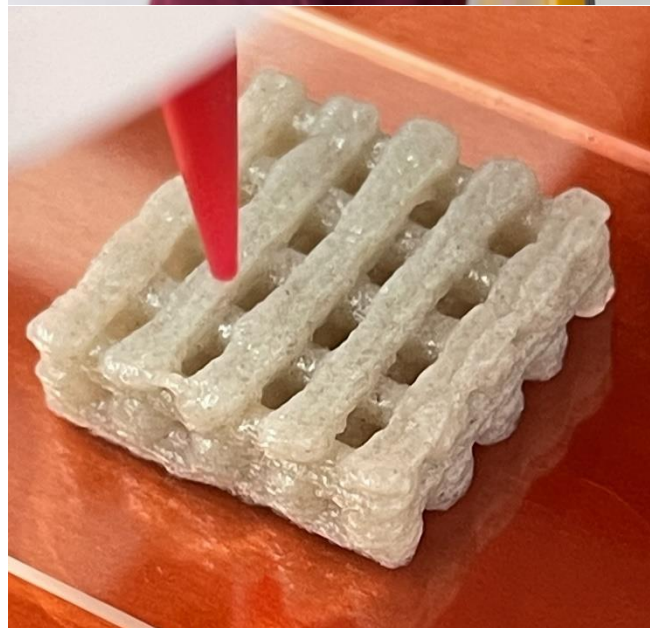
approval for DME as a permitted food-processing agent. This would allow export of New Zealand's DME-extracted marine products to South Korea.



Michael Treadwell operating the mid-size dimethyl ether plant at Callaghan Innovation.

Fish collagen for regenerative medicine

Very high-value/specialised collagens for medical use are a likely future addition to the Cyber-Marine cascades. In a PhD programme through UoO, native collagen from hoki skin was used to make regenerative tissue scaffolds. The work included: development of effective non-damaging sterilisation techniques; cross-linking to improve the mechanical and thermal resilience; processing to form an extrudable bioink for 3D printing; and embedding of growth factors for stem cell vascularisation within the scaffolds.



PhD student Alex Leonard (BSI and UoO) has created a collagen bioink that can be printed into a 3D tissue scaffold. Alex submitted her PhD thesis in July 2025 'Tissue engineering with fish skin collagen: from extraction to vascularised soft tissue constructs'.

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Recognition for Cyber-Marine researchers

Cyber-Marine has been privileged to have an outstanding team dedicated to doing great science, improving sustainability and making our industry more profitable. It ranges from industry partners and students through to senior researchers. It has been led by four Fellows of Te Apārangi/Royal Society of NZ (BSI/PFR, CI, VUW, UoO) and two joint Fellows of the Institute of Electrical and Electronics Engineers and Fellows of Engineering New Zealand (VUW). Sue Marshall became the most recent Te Apārangi Fellow in the 2025 celebrations. Mengjie Zhang and Bing Xu have collected three further international accolades for their work in artificial intelligence/machine learning.



Sue Marshall and Owen Catchpole at Te Apārangi/Royal Society of NZ Fellowship celebrations in April 2025

Ivy (I-Ming) Liu has been an important member of the C-M research team and is Deputy Director of the Centre for Data Science and Artificial Intelligence at VUW. This year she was promoted to Professor in the School of Mathematics and Statistics.

Outputs

Chunyu Wang, Qi Chen, Bing Xue, and Mengjie Zhang. "Semantics-guided multi-task genetic programming for multi-output regression." *Pattern Recognition* 161 (2025): 111289.

Dhakal, S, Nalder TD, Marshall SN., Barrow CJ (2025) Analytical approaches for rapid characterisation of marine glycolipids in bioproduct discovery. *Marine Drugs: Special Edition* 23 (9) <https://www.mdpi.com/1660-3397/23/9/352>

Wood, J., Nguyen, B., Xue, B. et al. Hook, line, and spectra: machine learning for fish species identification and body part classification using rapid evaporative ionization mass spectrometry. *Intell. Mar. Technol. Syst.* 3, 16 (2025). <https://doi.org/10.1007/s44295-025-00066-3>

Bing Xue delivered a keynote talk on "Artificial Intelligence for Aquaculture" in the World Marine Science and Technology Conference 2024, Qingdao, China, 20-22 September 2024.

Mengjie Zhang, Keynote talk on Evolutionary Machine Learning: 50 Years of Progress at IEEE World Congress on Computational Intelligence/ IEEE Congress on Evolutionary Computation (WCCI/CEC 2024). Yokohama, Japan, 30 June - 5 July 2024

Mengjie Zhang was invited to attend the Ocean University of China's 100 years anniversary celebration on 23-26 October 2024, and delivered a talk on "Evolutionary Machine Learning: Research, Applications and Challenges".

Owen Catchpole gave an invited Plenary lecture in South Korea at the 'SuperGreen' international conference held in Nov-Dec 2024 Yeosu Belle Mer, South Korea entitled "Development of CO₂ + ethanol and dimethyl ether extraction technologies for extraction of natural products: a New Zealand perspective"

Owen Catchpole gave an invited Keynote lecture "Gas eXpanded Liquid (GXL) extraction of marine biomass" in Bali at the ISSF-ISHA triannual premier supercritical extraction conference June 2025.

Zhixing Huang, Bing Xue, Mengjie Zhang, Jeremy S. Rooney, Keith C. Gordon, and Daniel P. Killeen, "Designing New Data Augmentation Functions for Fish Spectral Data by Genetic Programming". *Proceedings of 2025 Genetic and Evolutionary Computation Conference (GECCO 2025)*, Conference Companion.

Engineering New Zealand article (on-line edition of EG magazine, and via LinkedIn post)

["I want us to be part of the solution..." | Engineering NZ](#)

Interview by Matt Philps from Engineering NZ Magazine [EG Magazine | Engineering NZ](#) about C-M and engineering.

Sue Marshall presented "Seafood Processing Co-products" at the Moananui 'Scale to Tail' Workshop, Nelson April 2025

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Zhixing Huang, Bing Xue, Mengjie Zhang, Jeremy S. Rooney, Keith C. Gordon, and Daniel P. Killeen, "Designing New Data Augmentation Functions for Fish Spectral Data by Genetic Programming". Proceedings of 2025 Genetic and Evolutionary Computation Conference (GECCO 2025), Conference Companion. ACM Press. Malaga, Spain, 14-18 July, 2025, Hybrid Conference. 4pp

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

If you have any feedback or would like to talk more about Cyber-Marine, please contact Mark Jarvis: mark.jarvis@plantandfood.co.nz

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