



Cyber-Marine

Newsletter 1 | June 2021

Welcome to our very first newsletter. These will be coming out twice yearly, and along with an industry symposium, will keep you up to date with happenings and outputs in our innovative new research programme.

A new approach to processing

Cyber-Marine (real name 'Cyber-physical seafood systems: Intelligent and optimised green manufacturing for marine co-products') is an MBIE Endeavour research programme that started in October 2020. It will run for 5 years and has a budget of \$16.28m. It pulls together a worldleading team of chemists, biochemists, engineers and computer scientists from Plant & Food Research, Callaghan Innovation, Victoria University of Wellington, University of Otago, and Deakin University in Australia, and includes staff and facilities from companies across the New Zealand seafood industry. In Cyber-Marine we are also building links with our colleagues in the Marine Biotechnology Group at Nofima in Norway. The group is led by Dr Ragnhild Dragoy <https://nofima.no/en/employee/ragnhilddragoy/>.

Together, we're going to process fish in new ways and optimise the sustainable use of global marine resources.

An overview of the programme and its aims can be found in the February Seafood NZ magazine https://www.seafoodnewzealand.org.nz/fileadmin/documents/SNZ_Magazine/SNZ_Magazine_February_2021.pdf on page 49.

Science Advisory Group

We are fortunate to have very skilled and experienced people on our SEAG (Science Excellence Advisory Group, see bios). They're bringing highly relevant and wide-ranging scientific, business and industrial expertise to our programme. The role of the SEAG is to help keep our science on track and of the highest quality, whilst retaining relevance to industry and Māori stakeholders. The first meeting was held on 24th May.

Dr Jie Lu



Distinguished Professor Jie Lu is an internationally renowned scientist in the areas of computational intelligence, specifically in fuzzy transfer learning, concept drift, decision support systems, and recommender systems. She is the Director of the Centre for Artificial Intelligence (CAI), and the Associate Dean (Research Excellence) in the Faculty of Engineering and Information Technology at the University of Technology Sydney (UTS). She has published six research books and over 450 papers.

Dr Cushla McGoverin



Dr Cushla McGoverin is Senior Research Fellow in the Department of Physics, University of Auckland, where she is a member of Dr Frederique Vanholsbeeck's team analysing microbes with fluorescence spectroscopy.

Cushla brings strong links to our collaborators at UoO having studied there for her PhD (dairy products and pharmaceuticals with Raman spectroscopy) followed by work on spectroscopic applications for industry. She is interested in the ways different forms of spectroscopy can be used to solve analytical problems. Examples of her work include: mid- and near-infrared spectroscopy to assess native and

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engineered cartilage quality; near-infrared spectroscopy for the classification of maize hardness and pre-germination of wheat, sorghum and barley; Raman spectroscopy for component quantification in milk products; and using Raman spectroscopy to better understand drug delivery and the solid state of pharmaceuticals.

Greg Summerton



Greg's whakapapa traces back to Rākaihautū, the Waitaha, and Ngāi Tahu connection is also of great importance to him.

He specialises in the application of the NZ Quota Management System to develop business strategies based around the principles of sustainability, longevity, and innovation. Greg's vision is to maximise Māori fishery assets through inter-generational and sustainable growth in global seafood export markets.

Greg is the founder and Managing Director of the Okains Bay Seafood Group, one of Aotearoa's largest privately owned and whanau-focused longline fishing companies. Throughout his 35 years' experience operating as a deep-sea Captain, Greg has developed a deep knowledge and appreciation for the cultural, commercial, environmental and social imperatives of the New Zealand seafood industry. His own business has a focus on sustainability, high-quality product, and is a carbon neutral operating model. Greg also acts in a governance capacity for a range of businesses involved in the seafood, agricultural and post-farm-gate sectors. He served for 7 years as a Director of Ngāi Tahu Seafood Limited, and has now joined the board of Moana.

Dr Johan Verbeek



Taking materials that would otherwise be thrown away and turning them into useful products has become the research focus for Dr Johan Verbeek. His work is mainly related to polymers and plastics: reactive

extrusion, rheology, protein analysis and nano-composites. Johan is the Director of the Plastics Centre of Excellence, within Mechanical Engineering, University of Auckland. He joined The University of Auckland after several years at Waikato University where he was the convener of the Chemical & Biological Engineering programme. Johan's biggest impact has been in developing protein-based thermoplastics, for which his research group is internationally respected. His work led to the establishment of the company Aduro Biopolymers, which produces Novatein, the only commercially available protein-based thermoplastic and is a joint venture between Wallace Corporation and the Maisey Group. Their flagship product, made of Novatein, significantly reduces faecal contamination during meat processing, and because it is made from blood meal, meat processors need not separate it from other waste before rendering, which offered a significant process improvement. While at Waikato University, Johan has been the Research and Development Manager for Aduro Biopolymers and was actively involved in Product Development. Other research involved using chicken feather fibres to reinforce thermoplastics as well as other topics such as the recovery of proteins from wastewater using nano-clay, protein oxidation and collagen recovery from waste sources.

Dr Tom Wheeler



Tom is Senior Scientist and Technical Manager of the Research and Method Development Team within Analytical Science at the Cawthron Institute. Since 2017, he has led research on the biochemistry of seaweeds with the goal of understanding their nutritional benefits, functional properties and utility as food ingredients. A biochemist by training, Tom has also applied his skills in protein analysis and purification to investigating the innate immune-related properties of milk proteins, hormonal control of mammary gland function and the role of salivary proteins in ruminant digestion.

Research Organisations

Plant & Food Research

Plant & Food Research (PFR) are the lead organisation for Cyber-Marine, drawing on 18 years of experience in managing and delivering large and

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successful MBIE/FRST marine-products programmes and the commercial projects derived from them. PFR's focus is on the application of spectroscopic techniques into industrial processes to deliver rapid high-quality analytical data from both in-process streams and end-products. They bring 'green' industrial processing expertise based on low-energy aqueous extraction/fractionation of components and the use of enzymes to manipulate molecules to change their functionality. PFR has extensive experience in the extraction and product development of collagens from marine organisms (e.g. ActivLayr™ cosmetic patches from NanoLayr <https://activlayr.com/>) with expanding the range and use of new collagen formats an important aspect of Cyber-Marine.

At PFR, Dr Sue Marshall is the programme lead. She will also drive development of new processing technologies in collaboration with Callaghan Innovation. The team has a wide range of skills with leads as follows: Dr Dan Killeen (analytical chemistry/spectroscopy); Dr Ivan Kurtovic (enzymology); Dr Mat Cumming (protein chemistry and molecular transformation); Dr Hemi Cumming (Māori student outreach, green chemistry) and Jacqui Day as programme coordinator.

Callaghan Innovation

Callaghan Innovation is providing its expertise in separation science, chemical engineering, analytical chemistry and lipid chemistry. Complementing the work at PFR and Deakin, Callaghan's suite of technologies feature supercritical extraction, enzymatic transformation, membrane fractionation and drying/dewatering technologies. They are using these technologies to perform primary separation of marine raw materials into lipid, protein and mineral fractions; and then will further fractionate the lipid fractions into concentrates, particularly those enriched in phospholipids. Their analytical and lipid chemistry expertise is supporting characterisation of input streams and outputs from the processing, and the development of the smart sensing that will guide process decision-making.

Callaghan Innovation's contribution will be guided by Dr Owen Catchpole. The team includes Drs Stephen Tallon, Teresa Moreno, Peter Dyer, Cynthia Sun (Processing and enzyme technologies); Drs Kirill Lagutin, Mikhail Vyssotski, Andrew Mackenzie, Kevin Mitchell, Andrew Lewis, Mrs Dawn Scott (Analytical and lipid chemistry) and Dr Cynthia Sun (Protein science).

Deakin Biotechnology Group

Alfred Deakin Professor Colin Barrow and his group at Deakin University has a long standing collaborative relationship with Plant & Food Research NZ and bring a range of expertise to Cyber-Marine. They have extensive experience in natural products chemistry,

food biotechnology and bioprocessing, with a strong track record in the lipid and enzymatic processing space focusing on omega-3 technology. Recently they have worked with industry partners such as CSF Proteins, Ridley, Green Eco Technologies and Mantzaris Fisheries, with an emphasis on sustainability and the use of green technologies to add value to low-value or 'waste' material from the agricultural and marine sectors.

Deakin's contribution to Cyber-Marine will be led by Professor Colin Barrow, and will include Dr Tim Nalder (post-doctoral fellow) and a PhD student.

University of Otago

The rapid analytical spectroscopy platform for Cyber-Marine will be led by Professor Keith Gordon, Head of the Chemistry Department at the University of Otago. His group has extensive expertise in vibrational spectroscopy, and are world-renowned for their Raman spectroscopy research. Keith's group has two major research interests, molecular electronics for exploring fundamental aspects of solar cells, and applied spectroscopy for rapid characterisation of diverse materials, including marine oils, textile fibres, geological minerals and pharmaceuticals. His group is also currently developing fibre optic probes for medical diagnostic applications. This diverse research experience provides solid footing from which to address the technical challenges associated with analyses of marine biomass samples in Cyber-Marine.

Victoria University of Wellington

Victoria University of Wellington has the largest research team in artificial intelligence (AI), machine learning and data science in New Zealand with over 20 academics, 7 postdoctoral research fellows, and over 40 PhD students. The team has a broad range of expertise in AI and machine learning, particularly in evolutionary and statistical learning. The team has been conducting fundamental research in these areas and applications to NZ primary industry (such as aquaculture, fishing, forestry and horticulture), biological and medical applications, cybersecurity, renewable energy, chemistry and materials, through collaborations with other research institutes, and partnering with companies such as IBM, Google, Microsoft, Huawei and Huayin Medical.

The team leaders Prof. Mengjie Zhang and Prof. Bing Xue are international authorities in AI, machine learning, image analysis and data processing. In Cyber-Marine, Professors Zhang and Xue are leading an AI team with a focus on the development of computer technologies to manage, interpret and integrate analytical data and develop the models to automate process decision-making. This includes data processing, interpretation and construction, data-driven model learning and prediction, interpreting model data features, and multi-objective optimisation and decision-making. The team is closely

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collaborating with the PFR and Otago teams to start building the computer models.

Activities

Cyber-Marine is hosting a teacher from the Royal Society Teaching Leadership Programme. The programme's aim is to build leadership skills for NZ's science teachers so that they can go back to their schools and make sure our kids are more critical thinkers, more scientifically capable and better equipped to function in a world where they are bombarded with information both true and not. At PFR in Nelson, our teacher, Mark Chamberlain, is doing experimental work and helping develop Cyber-Marine's Māori student outreach programme. Alongside this, we've all had many discussions about the nature of science, what it means to be a scientist and how to nurture a critical approach to problem solving.



Left to right: Dr Mat Wylie, Mark Chamberlain and Dr Ivan Kurtovic dissecting mackerel for analytical tissue samples.



PFR and Trinder Engineering staff: designing our first prototype spectroscopic sampling unit for inclusion into the developmental processing line. Left to right: Wayne Martin and Dr David Aitchison from Trinder; Dr Sue Marshall and Bodhi Bettjeman from PFR, with Dr Dan Killeen as photographer

Coming up...

We are planning an Industry Forum later in 2021 (in Nelson) where you can meet the team, find out more about what we're doing, and how you can get involved in the programme. The date will be announced soon.

Publications

Ahmed F, Fuller ID, Killeen DP, Fraser-Miller SJ, Gordon KC (2021) Raman and Infrared Spectroscopic Data Fusion Strategies for Rapid, Multicomponent Quantitation of Krill Oil Compositions. *ACS Food Science and Technology* 1(4): 570–578.

Ahmed et al was partially funded by CyberMarine, and partially by The University of Otago with contributors from PFR and UoO. It discusses the use of combined Raman and infrareds pectroscopy to measure omega 3 fatty acids and astaxanthin within gelatin capsules, and the potential to improve responses by combining the data from more than one instrument.

Robinson D, Chen Q, Xue B, Killeen D, Miller S, Gordon K, Oey I, Zhang M (2021) Genetic Algorithm for Feature and Latent Variable Selection for Nutrient Assessment in Horticultural Products. *IEEE Congress on Evolutionary Computation*. Peer reviewed conference publication

Robinson et al. represents an important first step in collaborative work between PFR, University of Otago and Victoria University of Wellington. In addition to improving respective understandings between these groups, this work provides evidence for one of the fundamental axioms of Cyber-Marine: that data combined from multiple spectroscopic inputs, greatly improves AI predictive model outputs.

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