Plant & Food™ Research
Rangahau Ahumāra Kai

Cyber-Marine

Industry Forum

12 April 2024

Plant & Food Research
Rangahau Ahumāra Kai

Cyber-Marine

Cyber-physical seafood systems: Intelligent and optimised green manufacturing for marine co-products

12 April 2024

Cyber-Marine

INDUSTRY FORUM

9:00	Morning Tea	
9:55	Opening mihi	Mat Cumming
10:00	Introduction to Cyber-Marine	Sue Marshall
10:15	Intellectual Property	Roz Murray
10:40	Product and Process Development	Sue Marshall, Owen Catchpole, Mat Cumming
11:25	Panel: Real-World Impact	Dan Killeen (Chair), David Aitchison, Paul Hufflet, Kirill Lagutin, Matt MacDonald, Bing Xue.
12:25	Closing	

Haven

Toilet

Toilet

Kitchen

We are here
Ika

1st floor

Front door (ground floor)

Car park

MBIE Endeavour Programme

- Research: Transformational change
- 5 years, finishing in October 2025
- $16.3 m

Best Team/Best Equipment

- Plant and Food Research
- Callaghan Innovation
- Victoria University of Wellington, University of Otago, Deakin University (Geelong, Australia)

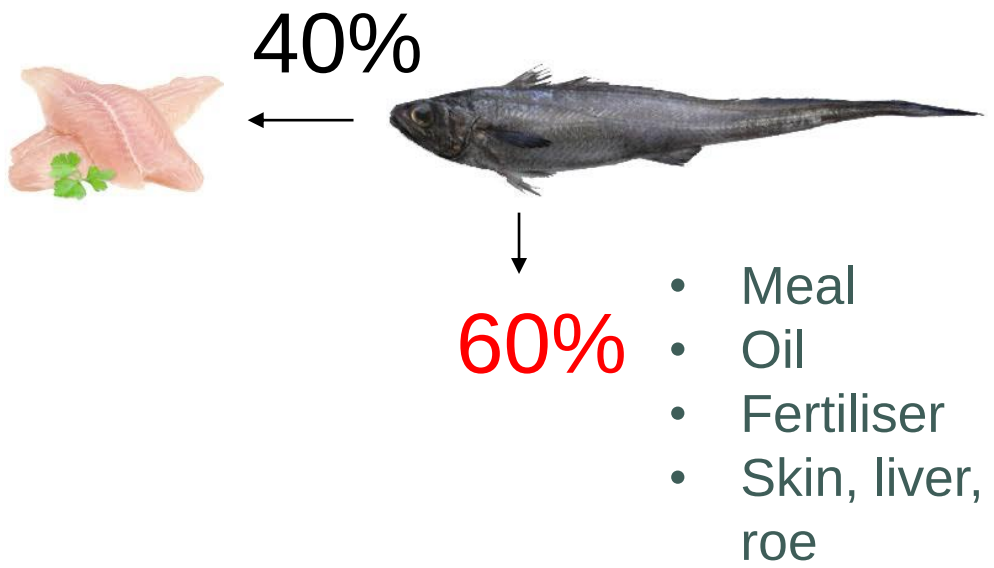
- Industry partners across NZ

“New Zealand's seafood industry plays a key role in the country's economy, contributing around $2 billion in export earnings and employing more than 16,500 people” Seafood NZ

Opportunities for increased value & sustainability

- >50% of a fish is not fillet. Bulk is rendered
- Not filleted, not caught to quota
  - Wild catch quota ~600,000 t : ~400,000 caught
  - Static or reducing quota/catch
- Increasing aquaculture so ↑ biomass and by-products

- Industry costs are high: people, equipment, energy, compliance, freight, waste handling
- Social licence
- Few new products



100% utilisation: Maximum value

- Food-grade. Automated
- Any species
- Reacts to complex, variable biological raw materials in real time
- Reacts to market demand
- Multiple products without tissue separation
- ‘Green’ processing: efficient, safe, sustainable

Vision: Marine products biorefineries for NZ

C-M: Transforming marine products processing

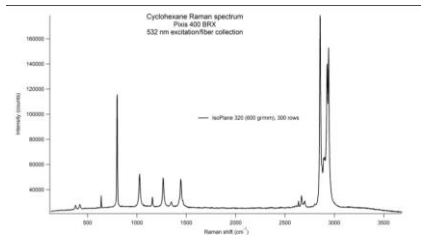
Milestone		
M1&2	What's in our marine raw materials? RIGHT NOW!	• In-line vibrational spectroscopy • Artificial Intelligence (AI)-integrated sensor systems to define composition in real time • Directed processing choices
M3	Getting all the components out in good condition Extraction	• Extraction of multiple primary extracts/molecules • Technology, energy, water, process chemicals, effluents, labour
M4	Novel 'Advanced' products with unique attributes Fractionation & Modification	Streams from 3 as starting material: Purification, cross-linking, hydrolysis and synthesis, complexes…
M5	Does C-M actually work? Is it economic?	System prototyping, yield, concept products
M6	**How do we get the research out to industry?**	

Shellfish

Underutilized whole fish

Filleting by-products

Laser spectroscopy



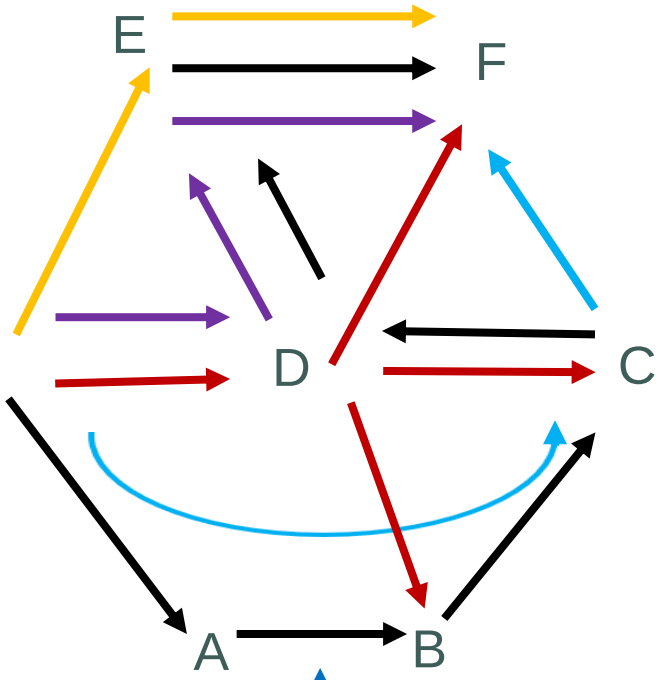
M1

Data input

Real-time composition

M2

Flexible factory



AI Controller

M3

Primary Extracts

Oil (neutral and polar)
Edible protein
Peptides
Enzymes
Collagen
Calcium

M4

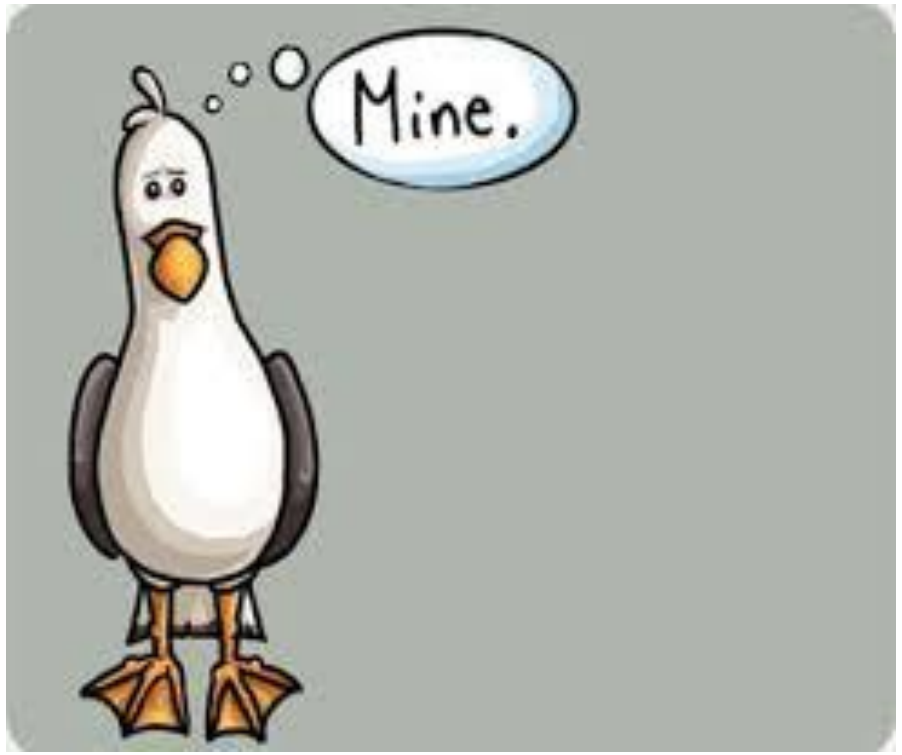
Fractionation. Chemical & structural modification,

Advanced Products

What I hoped Cyber-Marine was…

What I think OUTSIDERS think the role of an IP team is…

A guide to our IP strategy


Mine.


HAHAHA
JUST KIDDING
memegenerator.net

To talk IP strategy, I need you all on the same page…

First… what is IP?

Intellectual property (**IP**) is a term which refers to an **intangible** thing – the innovative idea behind new technology, products, processes, designs or plant varieties, and other intangible things such as trade secrets (including know how), goodwill and trademarks for which a **monopoly** is assigned to the designated owner by law.

Although intangible, the **law** recognises intellectual property as a form of **property** which can be sold, licensed, damaged or trespassed upon.

In English?…

Patents

Designs

Copyright ©

Trademarks ® and ™

Plant Variety Rights

Layout Design protection

Geographical indications

Trade Secrets

And the Most undervalued and forgotten

Know How

Why do we care?…

INTELLECTUAL PROPERTY HAS VALUE

IT PROTECTS RESEARCH AND COMMERCIALISATION EFFORTS (THIS WHERE THE HARD WORK IS)

IT MAKES BUSINESS ATTRACTIVE TO INVESTORS

REGISTERED IP PUTS THE LAW ON YOUR SIDE

YOU CONTROL WHAT HAPPENS TO YOUR IP

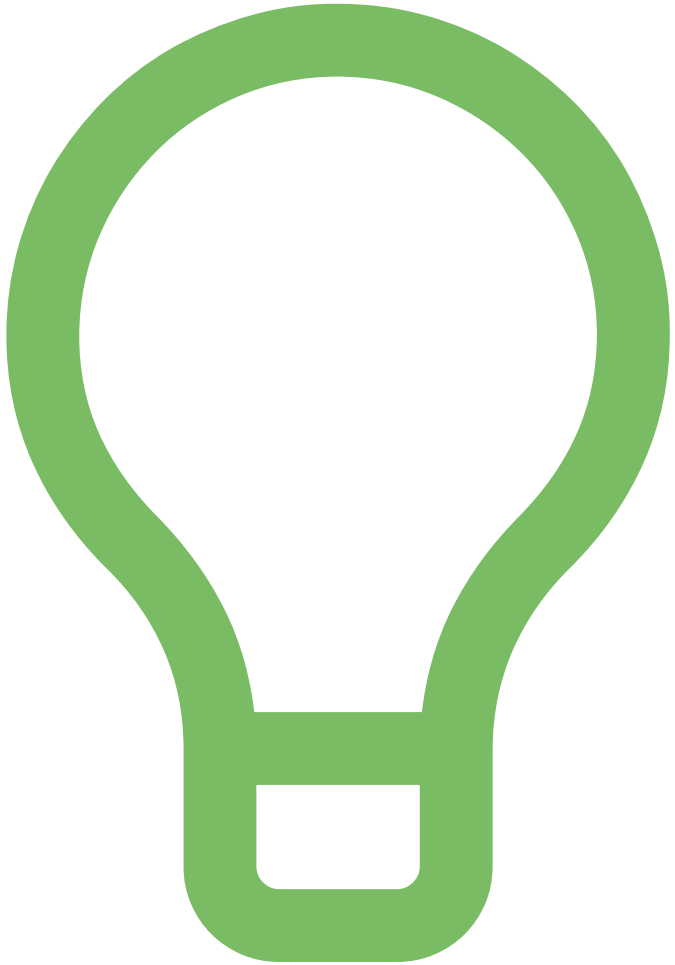
UNDERSTANDING IP AND HOW TO USE IT = COMPETITIVE ADVANTAGE

What IP is most important for C-M?

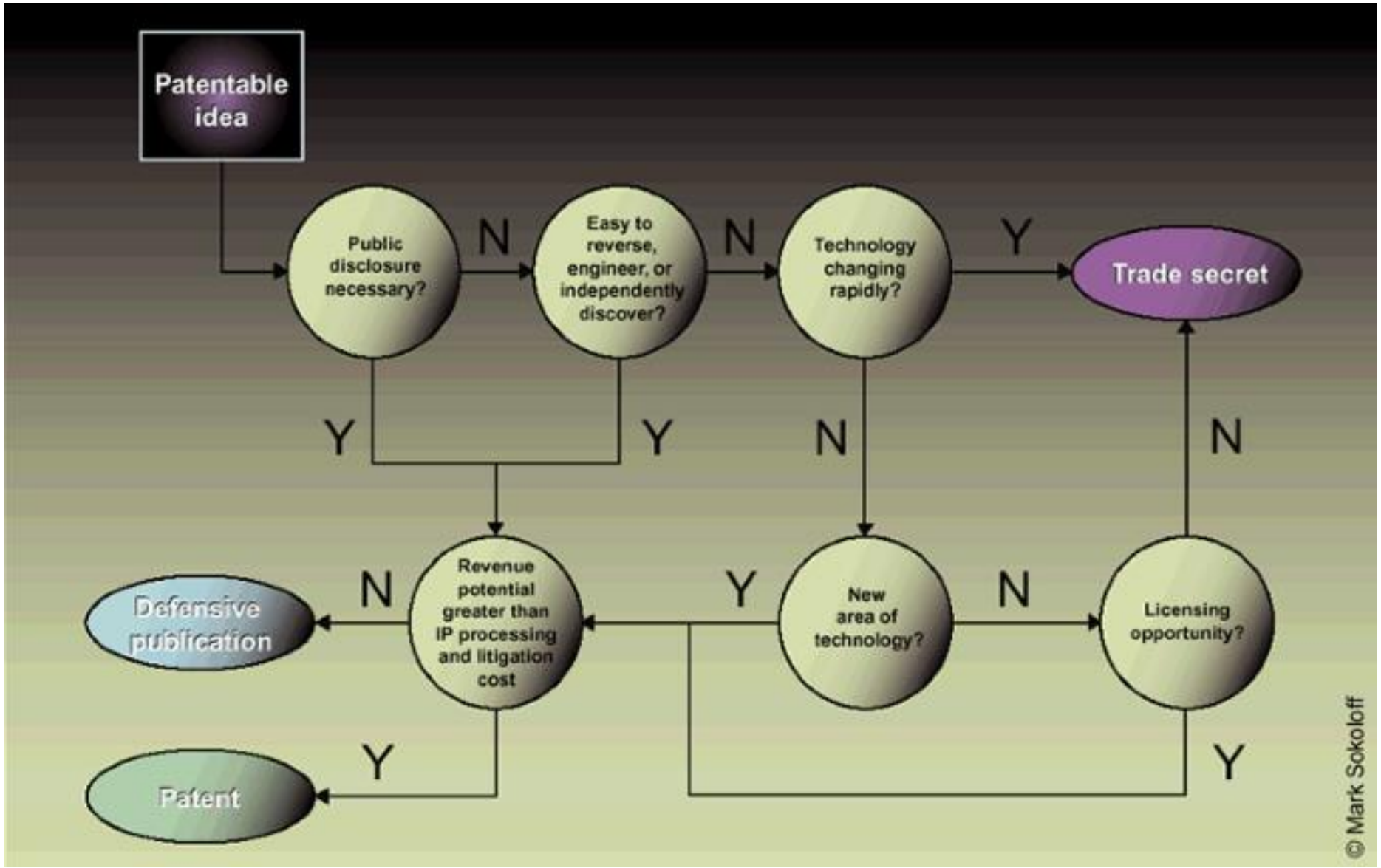
- Patents
- Copyright
- Trade secrets/Confidential information
- Know-how

Part of an IP role is to determine what CAN we protect and how best TO protect it

A commercialisation team determines if we SHOULD protect it

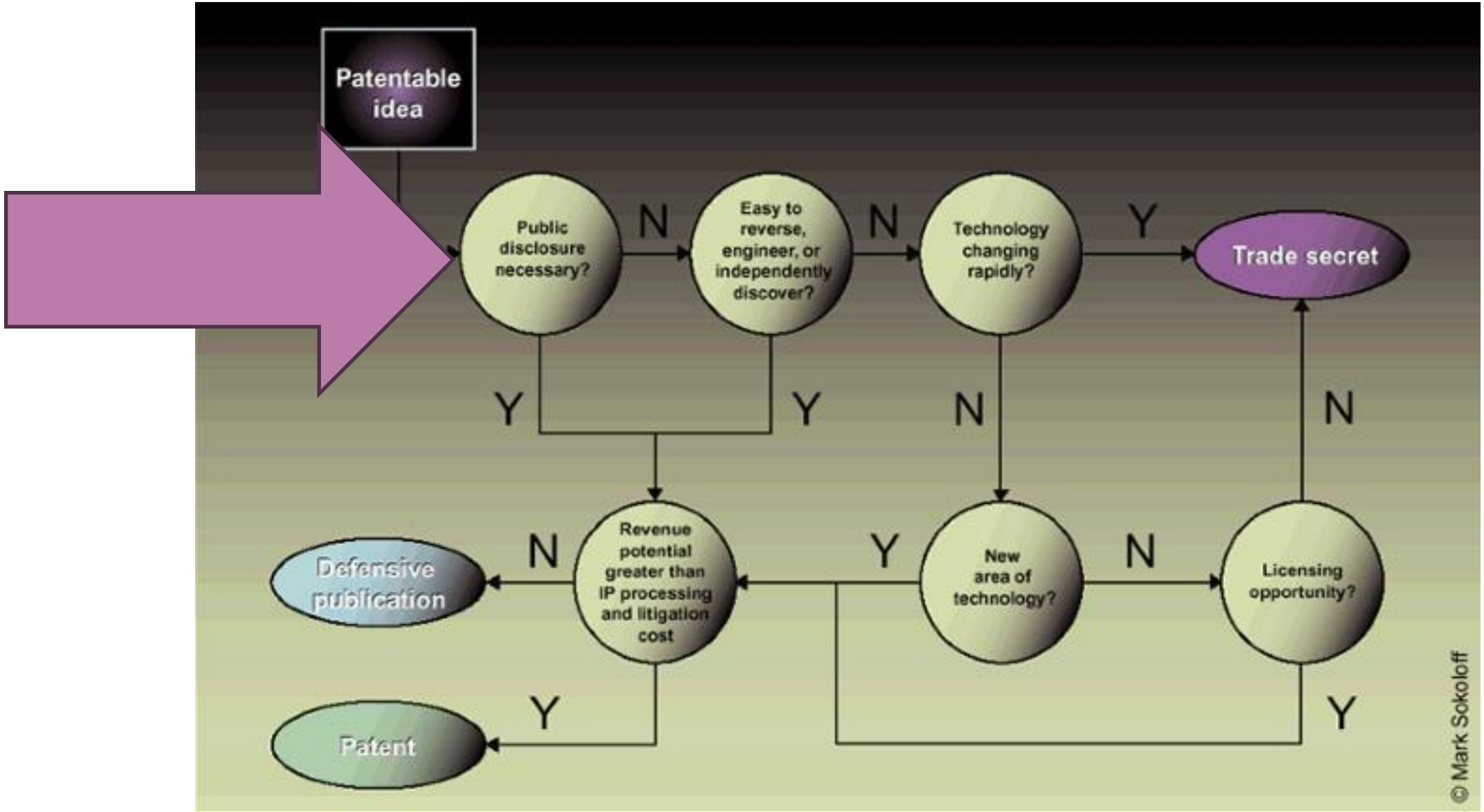


In a perfect world


Patentable idea
Public disclosure necessary?
N
Easy to reverse, engineer, or independently discover?
N
Technology changing rapidly?
Y
Trade secret
Y
Y
N
N
Revenue potential greater than IP processing and litigation cost
N
Defensive publication
Y
New area of technology?
N
Licensing opportunity?
Y
Patent
Y
© Mark Sokoloff

In reality

- Innovation comes in fits and starts
- Timing is everything – and so we need to make sure we have NDAs in place first to secure IP options
- The decision to file a patent application can be complex
- The decision of whether to publish can also be complex
  - Make an informed decision around IP protection - then create a publication strategy
  - Publications can provide critical support during patent examination
  - Defensive publications can be useful
  - Well-timed publications can support a marketing initiative, product promotion


Patentable idea
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Revenue potential greater than IP processing and litigation cost
N
Defensive publication
Y
New area of technology?
N
Licensing opportunity?
Y
Patent
Y
© Mark Sokoloff

Patents

Cover **CONCEPTS**, which must be

- Useful
- Novel (NEW)
- Inventive (not obvious based on what is already known)

Hardest form of IP to obtain

Monopoly rights- **20 years** from filing date

No monopoly until GRANTED

Monopoly rights only in countries granted in.

AND….Patents Cost!

- Provisional $7-25k
- PCT $13k
- National Phase $100k
- Examination/grant $200k
- Renewals (20 yrs) $150k

- We keep our new ideas confidential while they are assessed
- If we disclose them publicly, we limit our options around protection
- We want to enable informed decision-making
  - Is it new?
  - **Do we have FTO?**
  - Is the technology in the field changing rapidly?
  - Does the invention protect a key part of the process? OR
  - Is there an easy way to easily innovate around the idea?
  - Can we “black box” it?

So what about C-M?

We have:

- Algorithms and datasets for training AI
- Known end products & potential unknowns
- Known methods of separation & potentially unknown ones
- Decision-making processes that provide tailored solutions for companies
- That value is enabled by the real-time/near real-time decision-making process, which is used to optimise the value of the input material
- This is a difficult outcome to achieve due to variations in composition of the input material
- The process will evolve over time (manual to AI control over time?)

So… why should NZ industry pay for it?

- C-M is tax-payer funded
- Industry pays taxes
- Therefore, hasn’t Industry already funded this research?

Why should NZ industry have to pay twice?

I’m so glad you asked!

I’m so glad you asked!

- Why should you get the results of this research for free versus someone else?
- Who decides who is most worthy to get it?

I’m so glad you asked!

- Does this mean the results should be publicly available?
- Should we make the results of this research free to all NZ’ers?
- How do we limit the dissemination of that knowledge to just NZ companies?

I’m so glad you asked!

- If the results are freely available, they are no longer patentable
- If you think the ideas were patented first, who paid for that process? (it’s not cheap)
- How are the IP costs recouped if it’s been given away?
- If the process/product is not patented, why would any industry invest time and money into developing a commercially valuable end item when they cannot stop their competitors from copying it?
- Those competitors have not had to invest in R&D, overcome implementation hurdles, convince the market of the value etc
- Competitors can enter the market with very little R&D spend

So… why do the Research Institutes want to own everything?

I’m so glad you asked!

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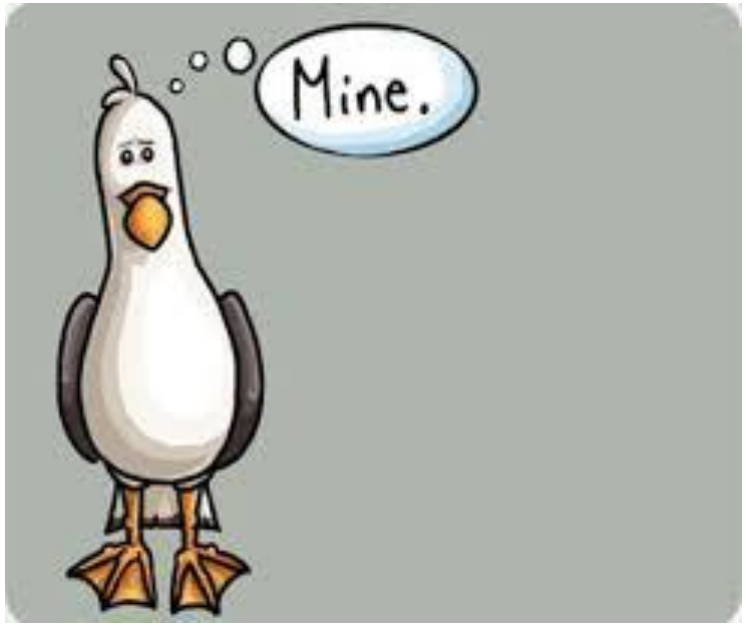
- Patent laws vary from country to country
- In some countries, where a patent is owned by more than one applicant, each applicant can work their patent independently.
- How do you negotiate an exclusive deal in that instance?
- What if you no longer get on?
- If you don’t have an exclusive license, how does a licensee have standing in infringement proceedings?

I’m so glad you asked!

- One solution is to have ONE applicant (owner)
- Have an agreement that addresses commercialisation of that technology (both costs and benefits) based on inputs (financial or intellectual) or the like
- IP can be assigned to new companies (JVs etc) when the timing is right.



No

Yes

Processes and products

Exemplar species: mackerel, hoki, GSM

Tailored technology solutions: paths to product

Primary Extraction

Raw material:

- Greenshell™: whole or marc
- Whole fish and by-products

Lipids and proteins

Unstable: hydrolysis, oxidation, denaturation

Where have we got to?

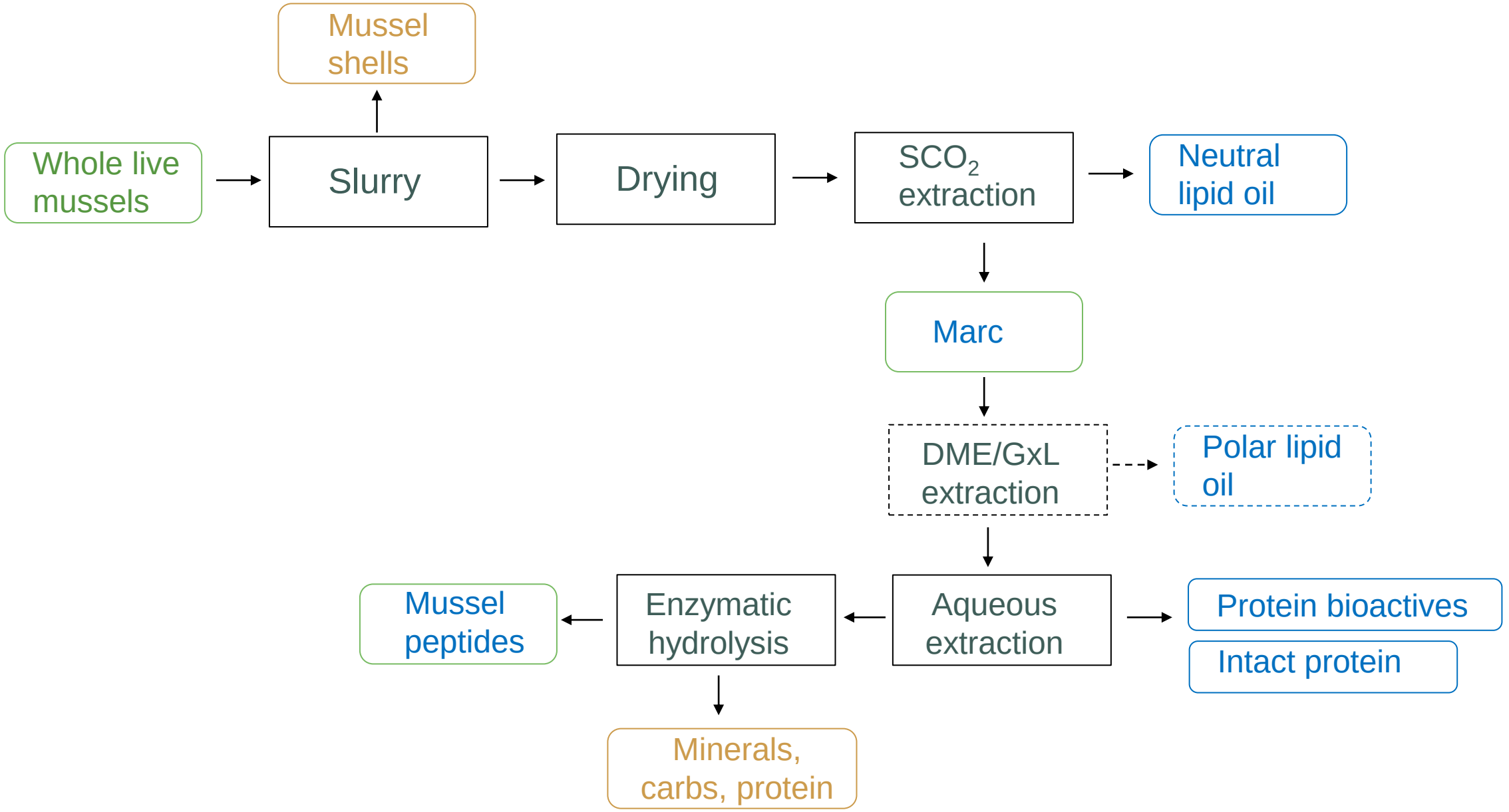
- Developing process and product options
- **Lipids out first, then the proteins**
- **Proteins first then lipids**

Greenshell™ mussel

Manufactured now	**Primary targets** (C-M in progress)
Powder ≥8 % lipid	Powder ≥8 % lipid
Oil: Bioactive neutral lipid (predominantly SFE)	Neutral lipid oil
	Phospholipid oil
Marc <8% lipid	High phospholipid ‘Marc’ ≥8 % lipid
	Protein/Protein hydrolysates (food, bioactives)
	Lipase/Phospholipase?

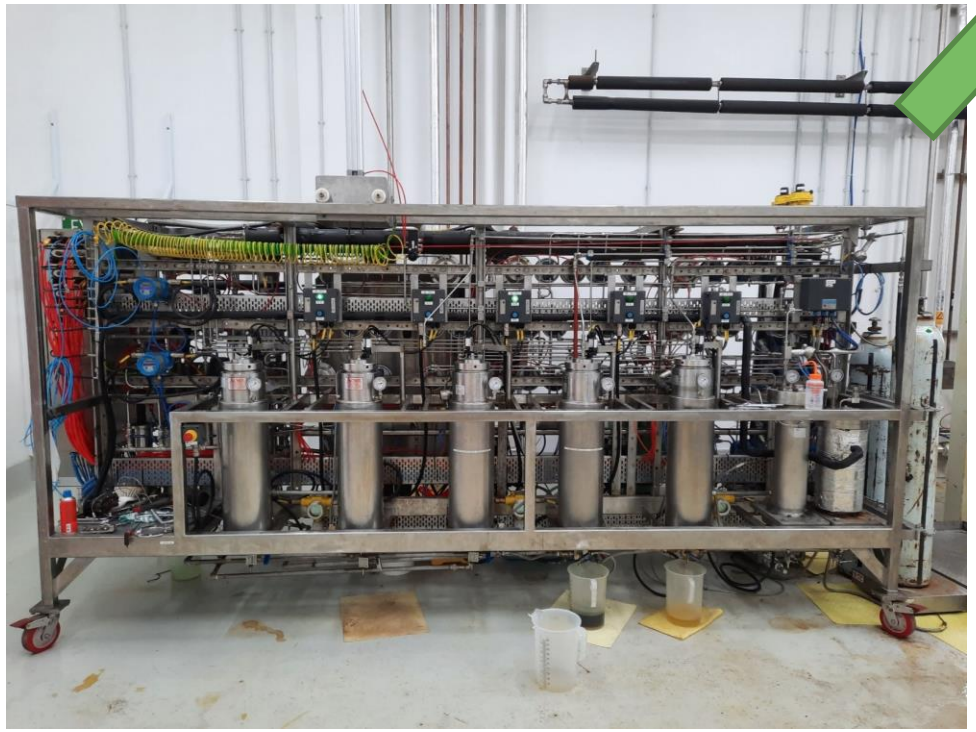
Aquaculture NZ
Quality mark. GSM only. Minimum 8% lipid.

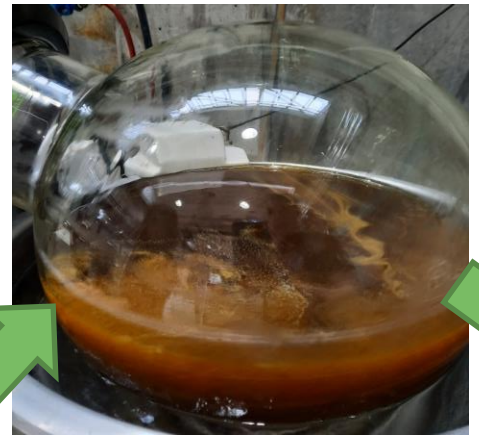
Example 1: Lipid first (Building on now)

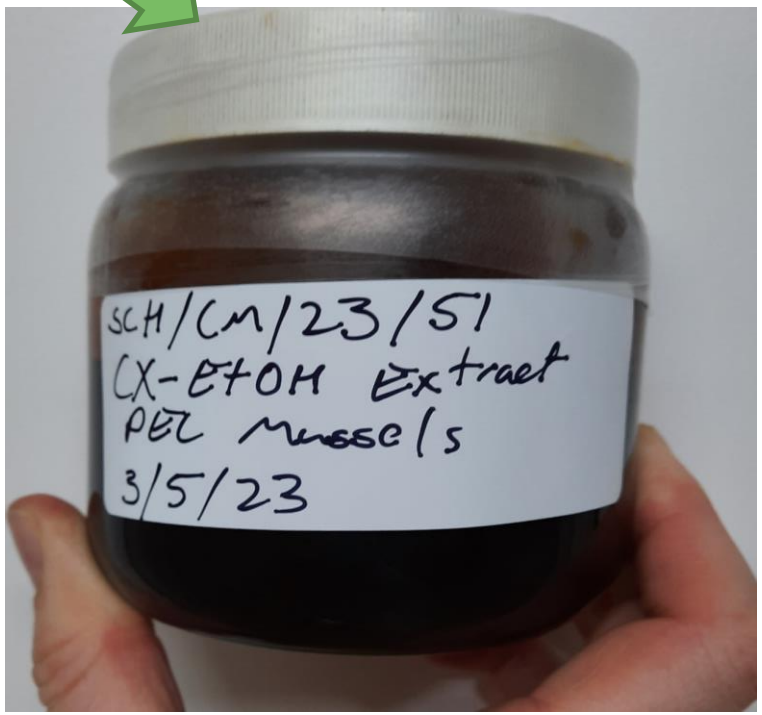


Scale-Up: 10 kg scale extractions DME or GXL

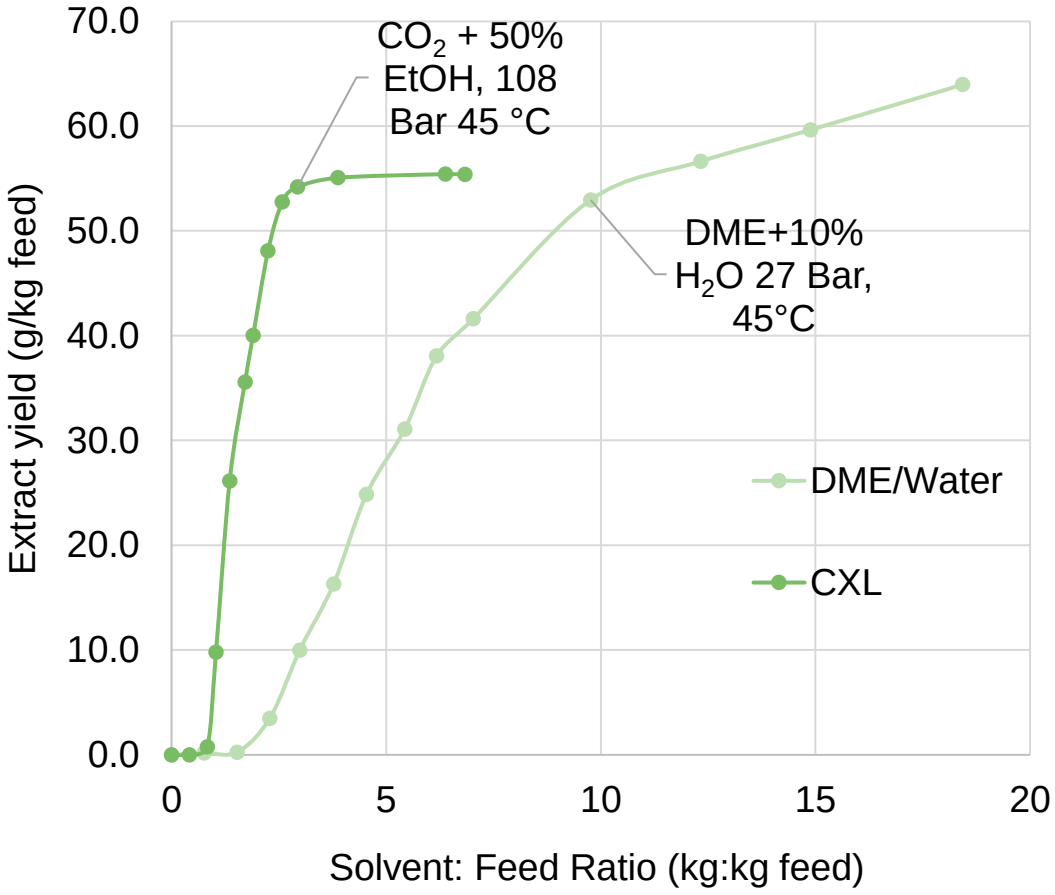
- Carried out on defatted mussel powders from commercial mussel oil manufacture
- Compared DME+10% H_2O with Gas eXpanded Liquid, 50:50 CO_2:ethanol

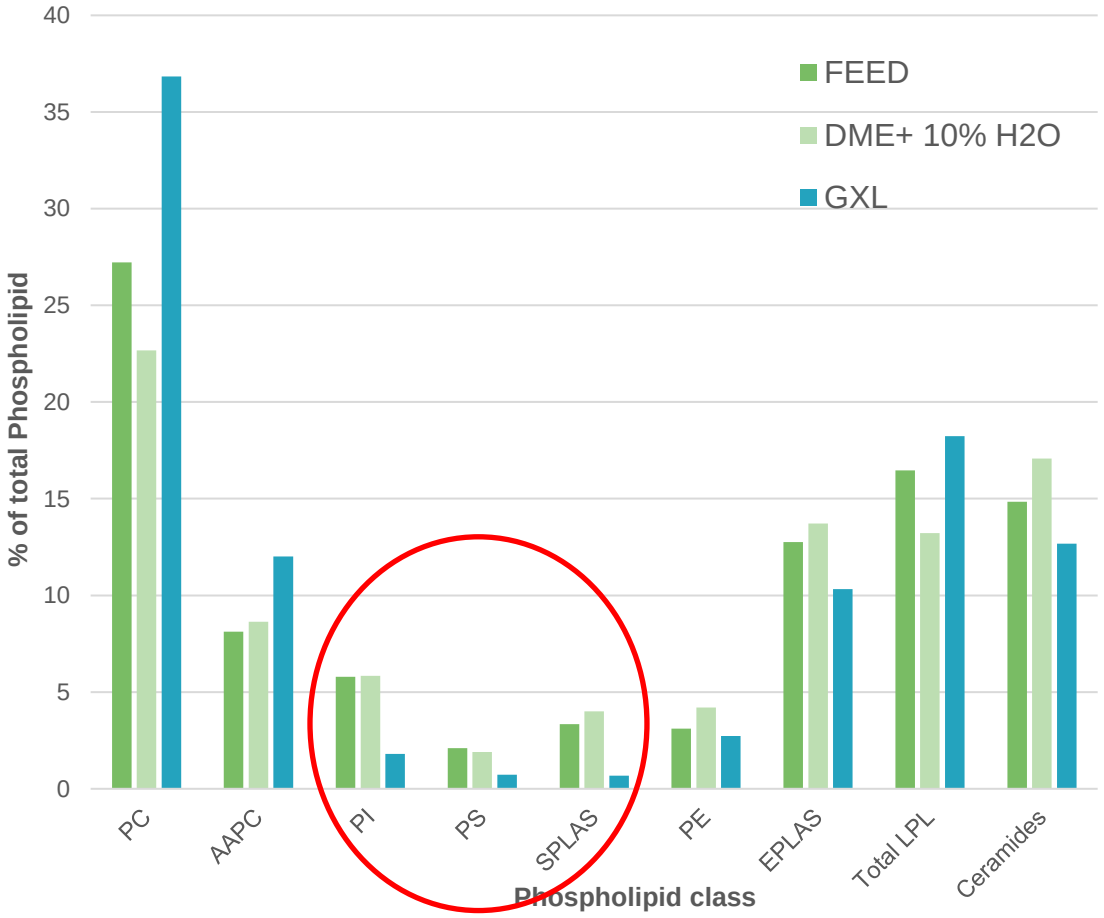






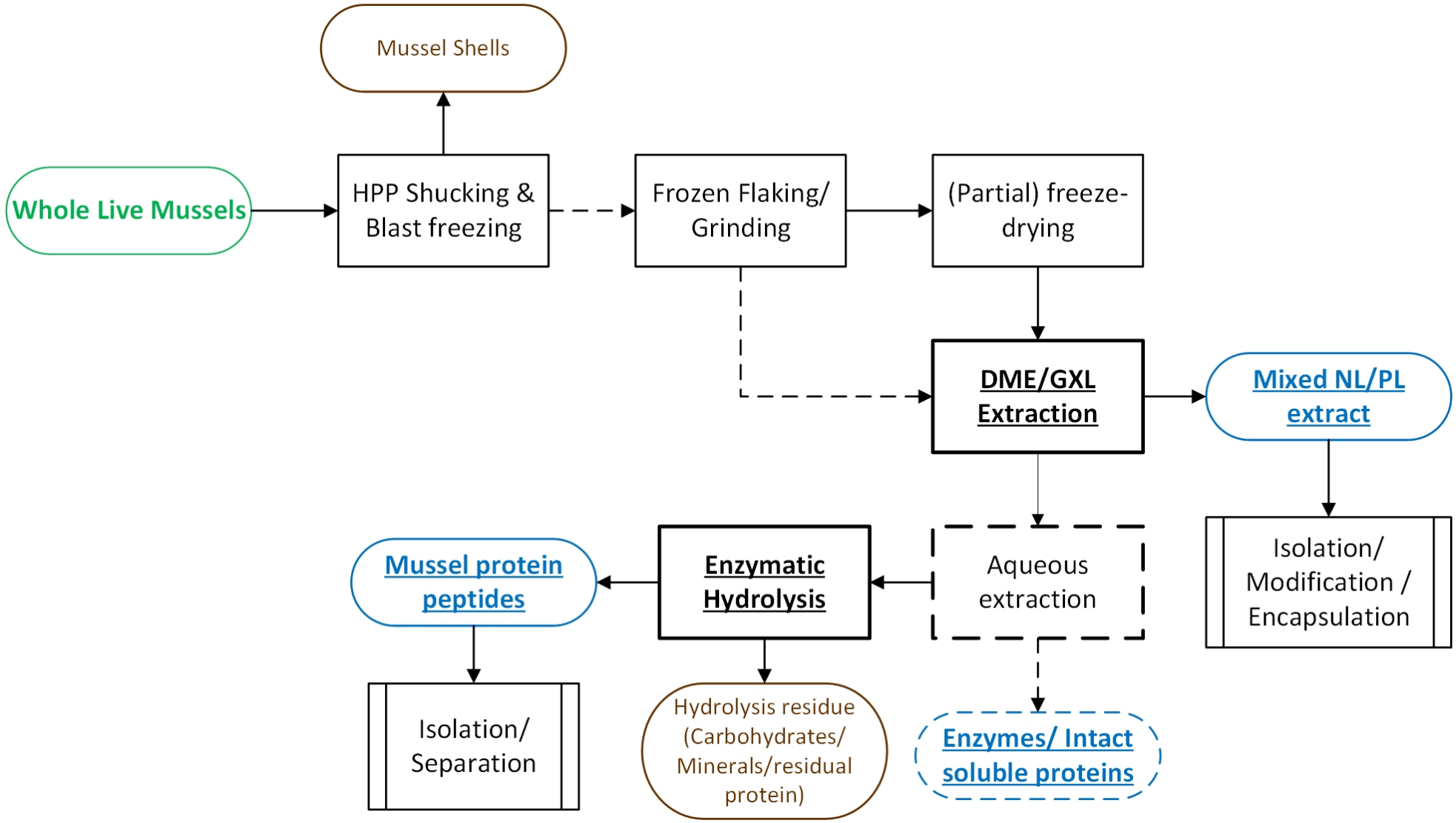
Scale-Up of DME and GXL : 10 kg scale extractions results





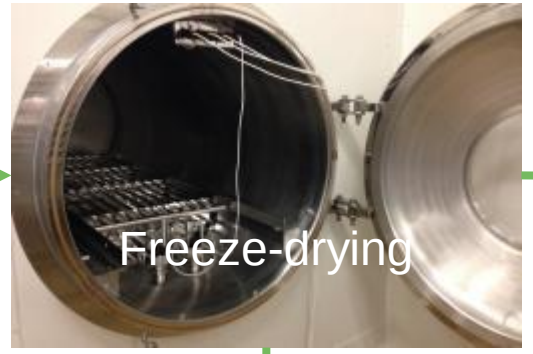
PI, PS, SPLAS less well extracted by GXL

Example 2: Lipid first (DME/Gas eXpanded liquid)



Processing Sequence: Mussel

Mince/
homogenise

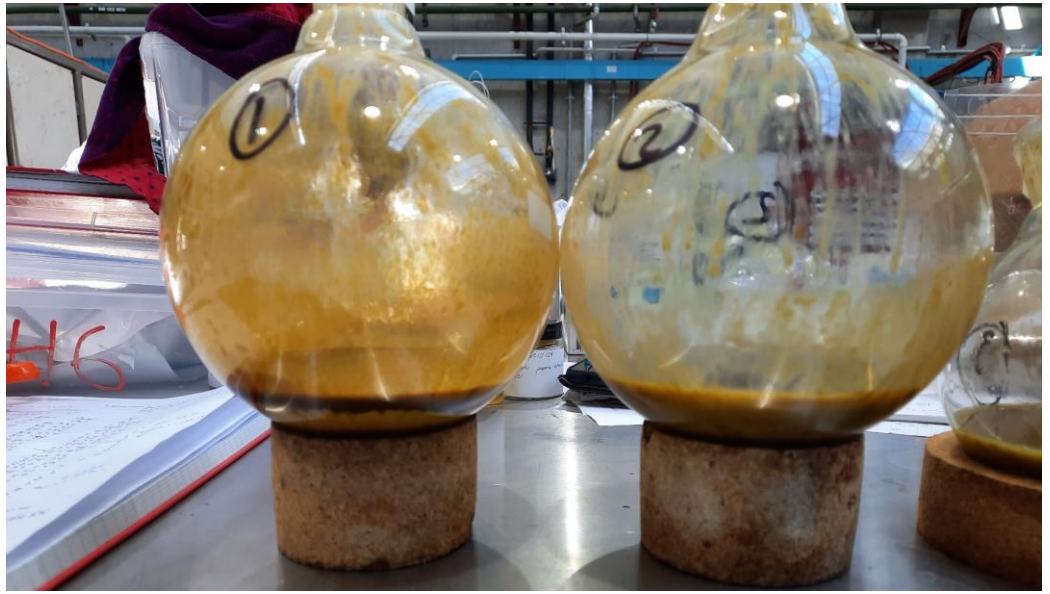


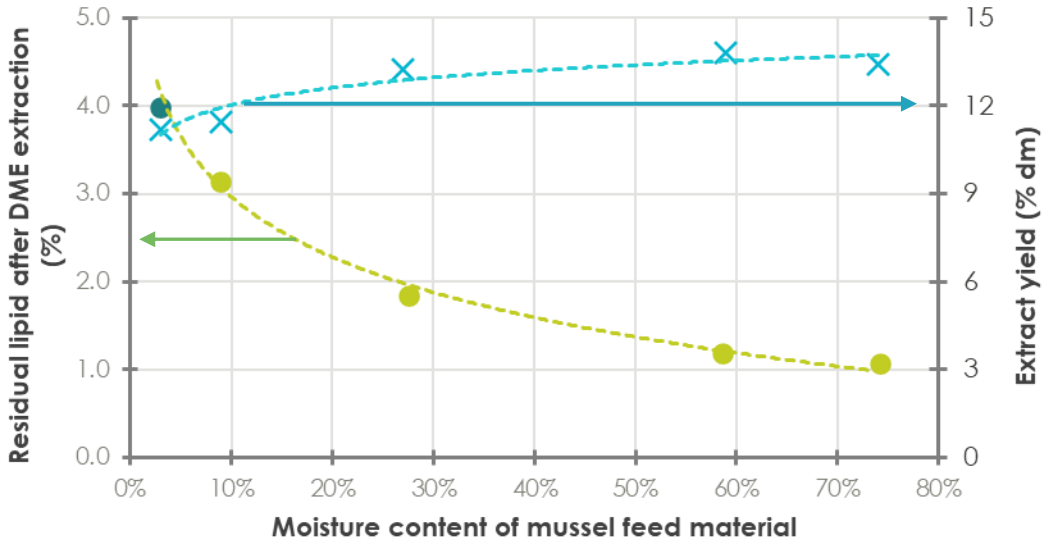
Partially dry

Optimise these steps

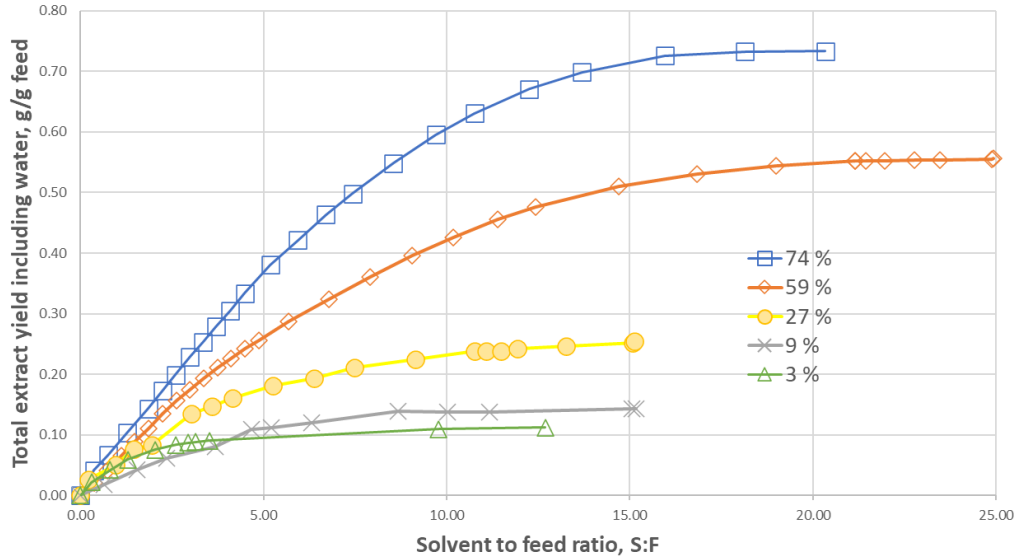
DME extraction from wet biomass

- CO_2 requires a dry feed material
- DME can extract lipids from a wet feed. Gives a two-phase extract
- ***Higher feed water contents gives an increase in lipid extraction with DME***



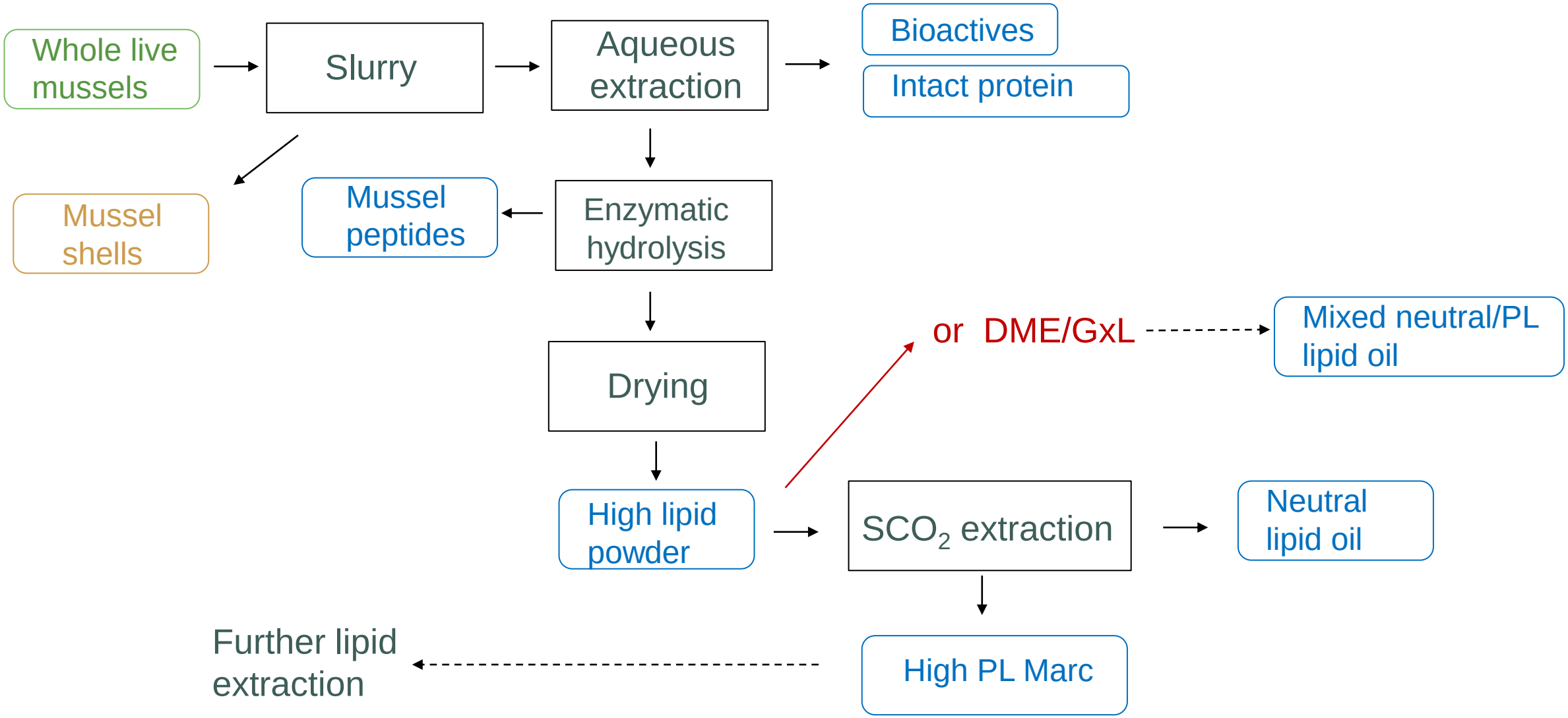


Dry lipid yield and residual lipid in marc dry basis



Total extract, water + lipid as a function of S:F

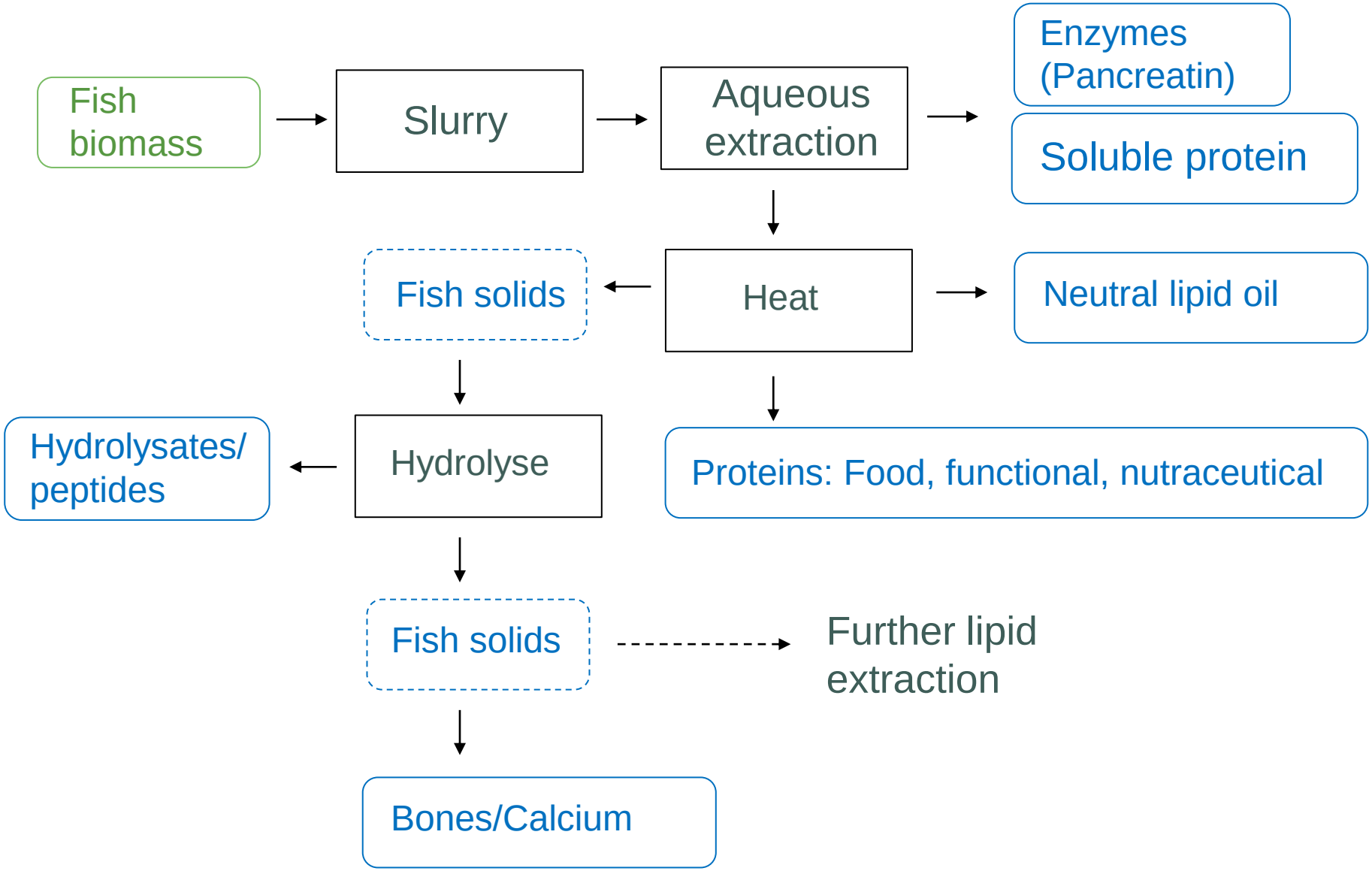
Example 3: Protein first



Fish (by-products, by-catch, low value fish)

Manufactured now	**Primary targets** (C-M in progress)
Omega 3 oil (rendered)	Omega 3 oil
	Phospholipid oil
Fishmeal & Stickwater (rendered)	Digestive enzymes
	Edible proteins
	Edible protein hydrolysates
	Collagen
	Bones/calcium

Example 4


Fish biomass
Slurry
Aqueous extraction
Enzymes (Pancreatin)
Soluble protein
Fish solids
Heat
Neutral lipid oil
Hydrolysates/ peptides
Hydrolyse
Proteins: Food, functional, nutraceutical
Fish solids
Further lipid extraction
Bones/Calcium

High-value market sectors (M4 Advanced)

- Biotechnology

Marine derived molecules used in manufacture of complex products: including enzymes, biopolymers and biomaterials

- Functional food and cosmetic ingredients

Natural preservatives, pigments, stabilizers, surfactants and gelling agents: may also have nutritional and cosmetic benefits

- Healthcare products

Purified, validated active ingredients: nutraceuticals, dietary supplements, prebiotics, (also wound dressings)

Marine products: Actively growing market

- Advanced marine product market ~$US 6.3B in 2020
- CAGR of 8.8%
- Total market size in 2025 ~$9.6B

- Food & Cosmetic products were valued at $1600 million in 2020 and growing to $2.4B by 2025 CAGR 9.3%

- Healthcare market segment within marine biotechnology in 2020 was worth $2.6B – 40% of marine product market.

Sources: TechNavio report – Global Marine Biotechnology Market 2021-2025;

Mellentin J 2024. 10 key trends in food, nutrition & health: report. London: New Nutrition Business;

2023 Coriolis reports for MPI; Creating beauty from New Zealand/ Marine bioactives from New Zealand

Cosmo Trends-Future view 2022-2027.

Food protein trends

- Mind and mood
- Sports performance
- Healthy aging
- Carnivore diet – High protein, low carbs

- Demand for animal protein is strong and growing

Modified proteins

Nutrient density: high quality protein in a palatable form (taste and texture)

- Dual functional ingredients that offer higher nutrition, taste, lower costs while providing functional benefits (preservatives, pigments, stabilizers, or gelling agents)

Cosmetic product trends

- Replacing synthetic chemicals with natural ingredients (currently only 8% of ingredients but growing)
- Sustainability: climate change and carbon reduction
- Hero ingredients: unique environment, ethical, circular and sustainable, innovative (science validation)
- Botanics (seaweed?)
- Reducing the ingredient list - Dual function ingredients, cosmetic benefits with functionality (e.g. preservatives, pigments, stabilizers, gelling agents)

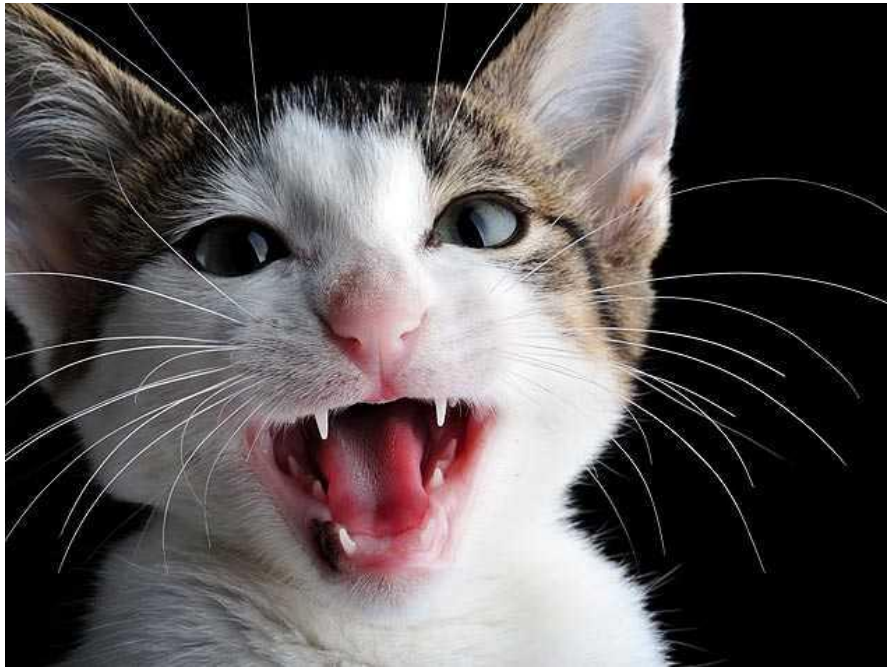
INGREDIENTS

Aqua, Cyclomethicone[1], Mica, Polybutene, Triisostearin, Prunus Persica Flower Extract, Betula Alba Oil, Lavandula Officinalis Oil, Paraffinum Liquidum, Propylene Carbonate, Methylparaben, Phenoxyethanol, Propylparaben, Lecithin, Alcohol Denat., BHT, Parfum[2], Aroma[3], Cinnamyl Alcohol, Citronellol, [+/- CI 15580[4], CI 45430[5]]

Nutraceutical/health product trends

Consumers are educated Generation X, health-conscious millennials, fitness conscious, and companion animals

- Digestive wellness, immunity, nurturing mood and mind for holistic happiness
- Stress reduction, digestive aids, cognition and improved sleep
- Collagen – No sign of slowing down
  - digestion aids, joint care, probiotics, and promoting sleep.
  - Fitness focused consumers
- Omega 3 (phospho) lipids for heart and brain wellbeing continues. Reducing menstrual/menopause symptoms
- Incorporation into food products

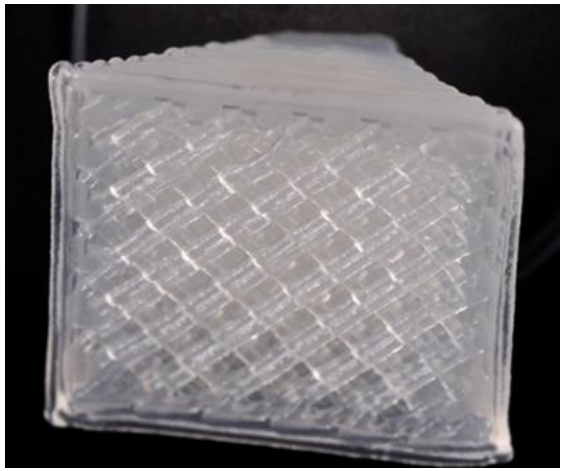


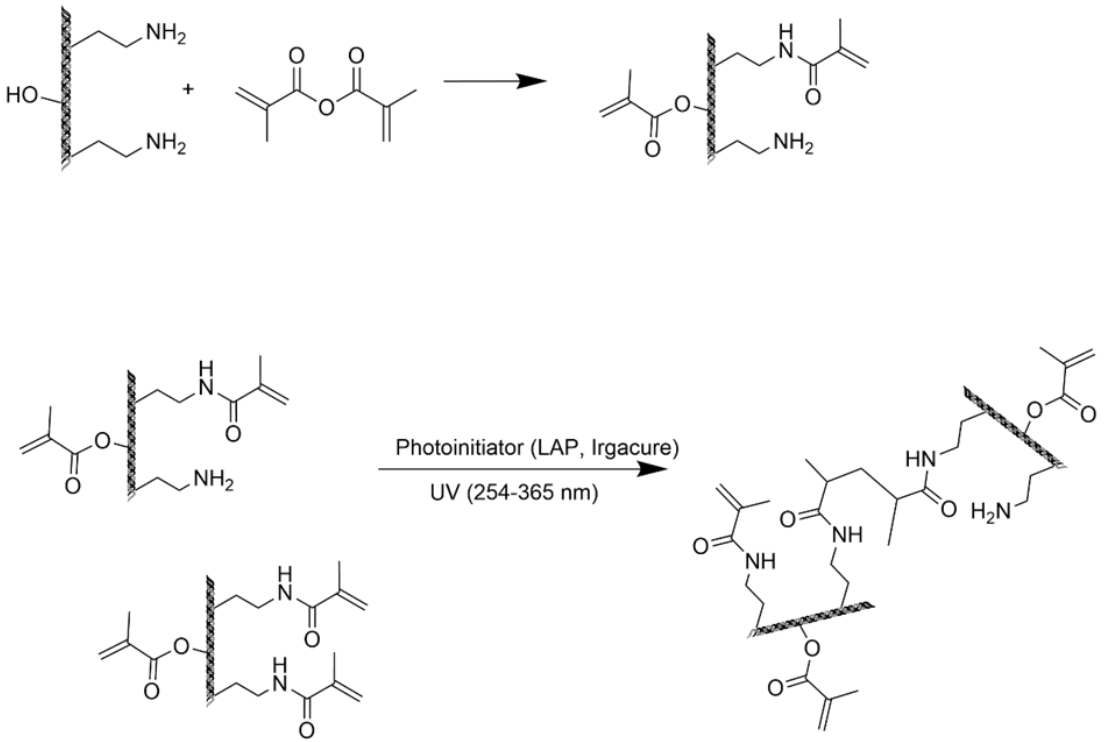
Cyber-Marine primary ingredient modification
Example 1: Marine Biomaterials for tissue engineering applications

University of Otago
ŌTĀKOU WHAKAIHU WAKA

Modified collagens for medical applications

- Functionalised marine collagens for 3D scaffolds. Growing human cells to build new tissue

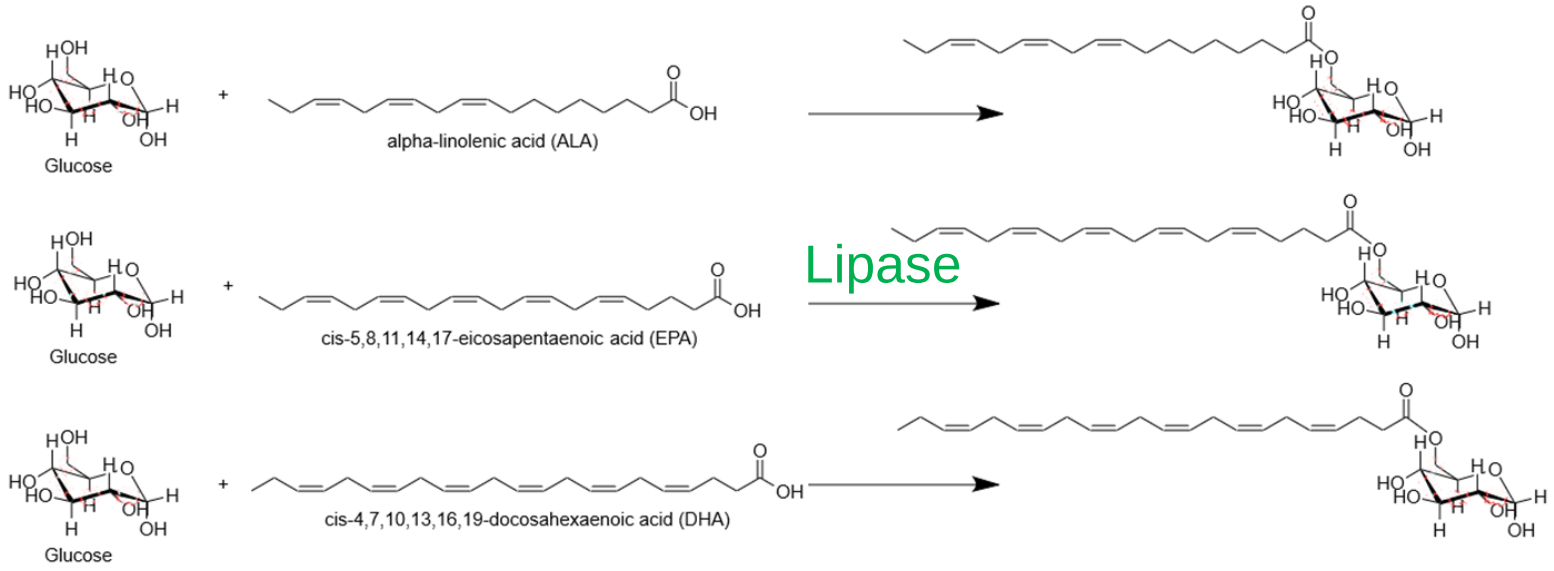




Leonard A.R, Cumming M.H, Ali A., Cabral J.D 2024 Fish Collagen Crosslinking Strategies to Improve Mechanical and Bioactive Capabilities for Tissue Engineering and Regenerative Medicine. *Submitted to Advanced Functional Materials*

Example 2– Green synthesis of novel glycolipids

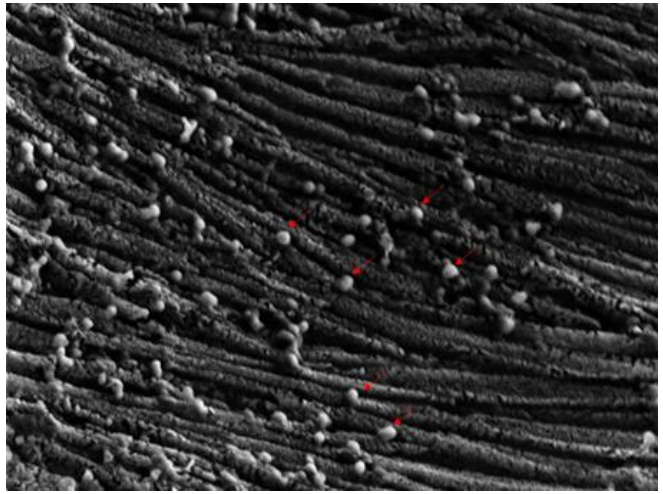
- Fatty acids from primary extraction + carbohydrate
- Rapid analysis, characterisation, scalable synthesis, purification, application
- Food-grade biosurfactants/emulsifiers for cosmetics, nutraceuticals, & food
- Secondary health benefits of soluble EPA/DHA

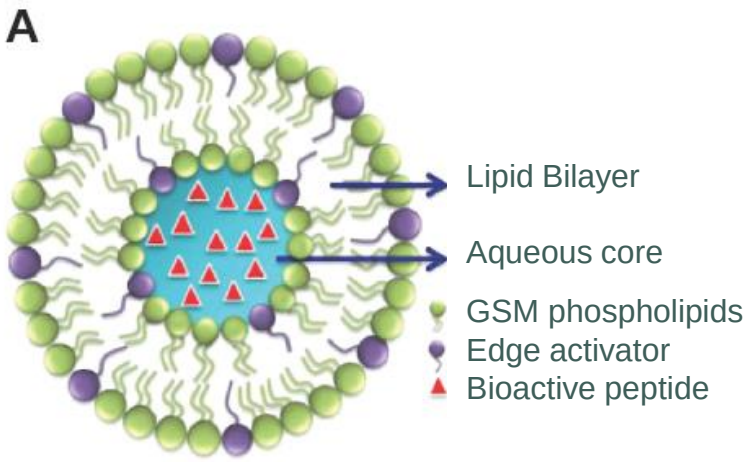


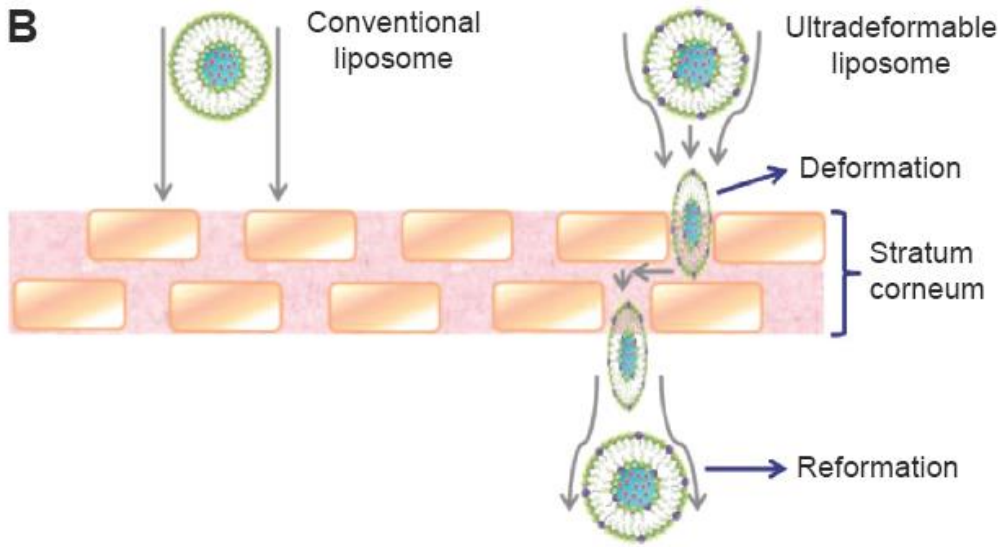
Deakin University PhD and post-doc/ Link to Australian Marine Bioproducts CRC

Example 3– Delivery of bioactive ingredients

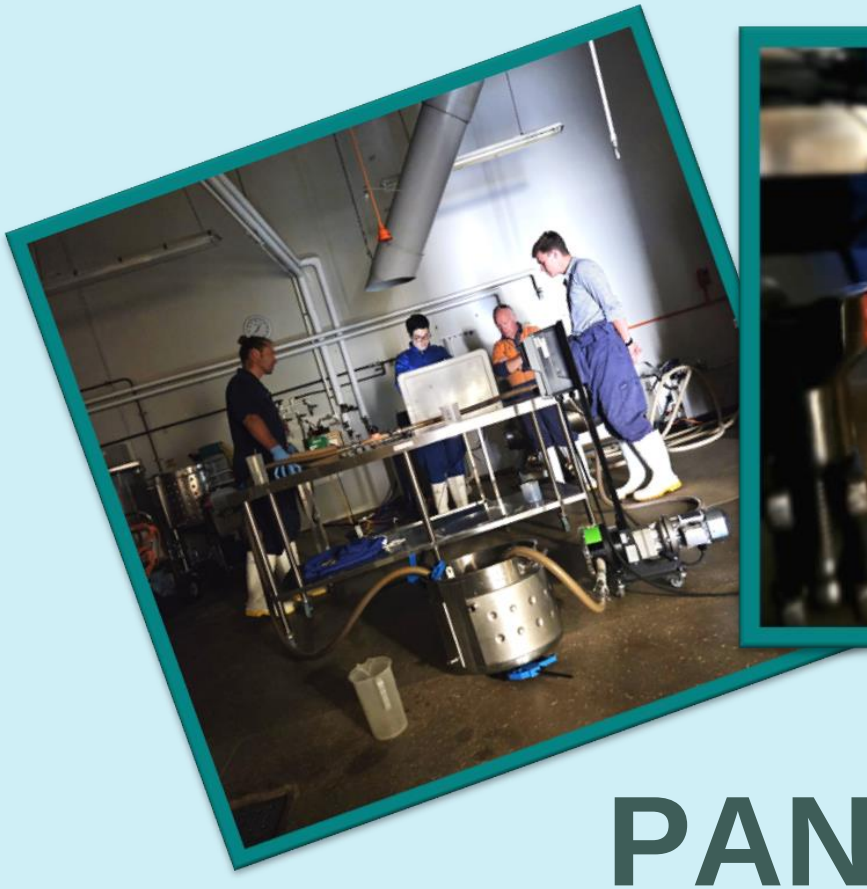
- Phospholipids and bioactive protein hydrolysates from primary extraction
- Liposomes created to deliver bioactives deeper into the skin
- Secondary health benefits of soluble EPA/DHA

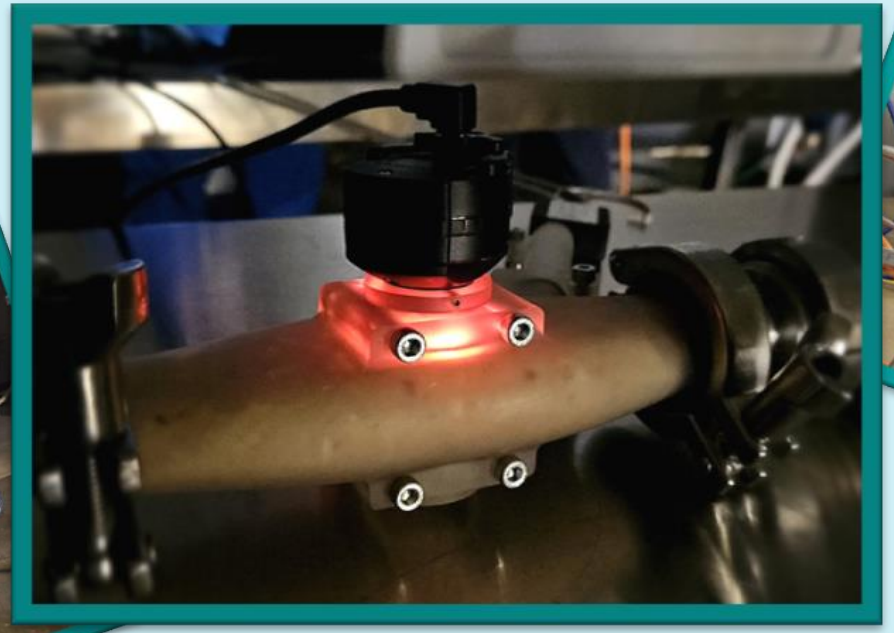






Cyber-Marine





PANEL DISCUSSION

Plant & Food Research
Rangahau Ahumāra Kai

Callaghan Innovation
Te Pokapū Auaha

University of Otago
ŌTĀKOU WHAKAIHU WAKA

VICTORIA
UNIVERSITY OF WELLINGTON
TE WHARE WĀNANGA
O TE ŪPOKO O TE IKA A MĀUI

DEAKIN
UNIVERSITY

Thank you

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