Plant & Food™ Research
Rangahau Ahumāra Kai

Seafood Technologies

Nau mai! Welcome!

A smart green future. Together.

Our mission

To create the world's most sustainable food production systems

Our strategic Research Themes

Healthy ecosystems

Positive foods

Aotearoa provenance

Climate resilience

Smart food systems

Full bioresource utilisation

Seafood Technologies

Our people & places

- 55 employees
  + PhD students, post-docs and casuals
- Two science groups:
  - ➢ Seafood Production (Maren Wellenreuther)
  - ➢ Seafood Processing & Marine Products (Sue Marshall)
- All based in Nelson (with exception of Food safety & Preservation team, based at Mt Albert)

Seafood Technologies Portfolio

Helen Mussely

Marine Products Group

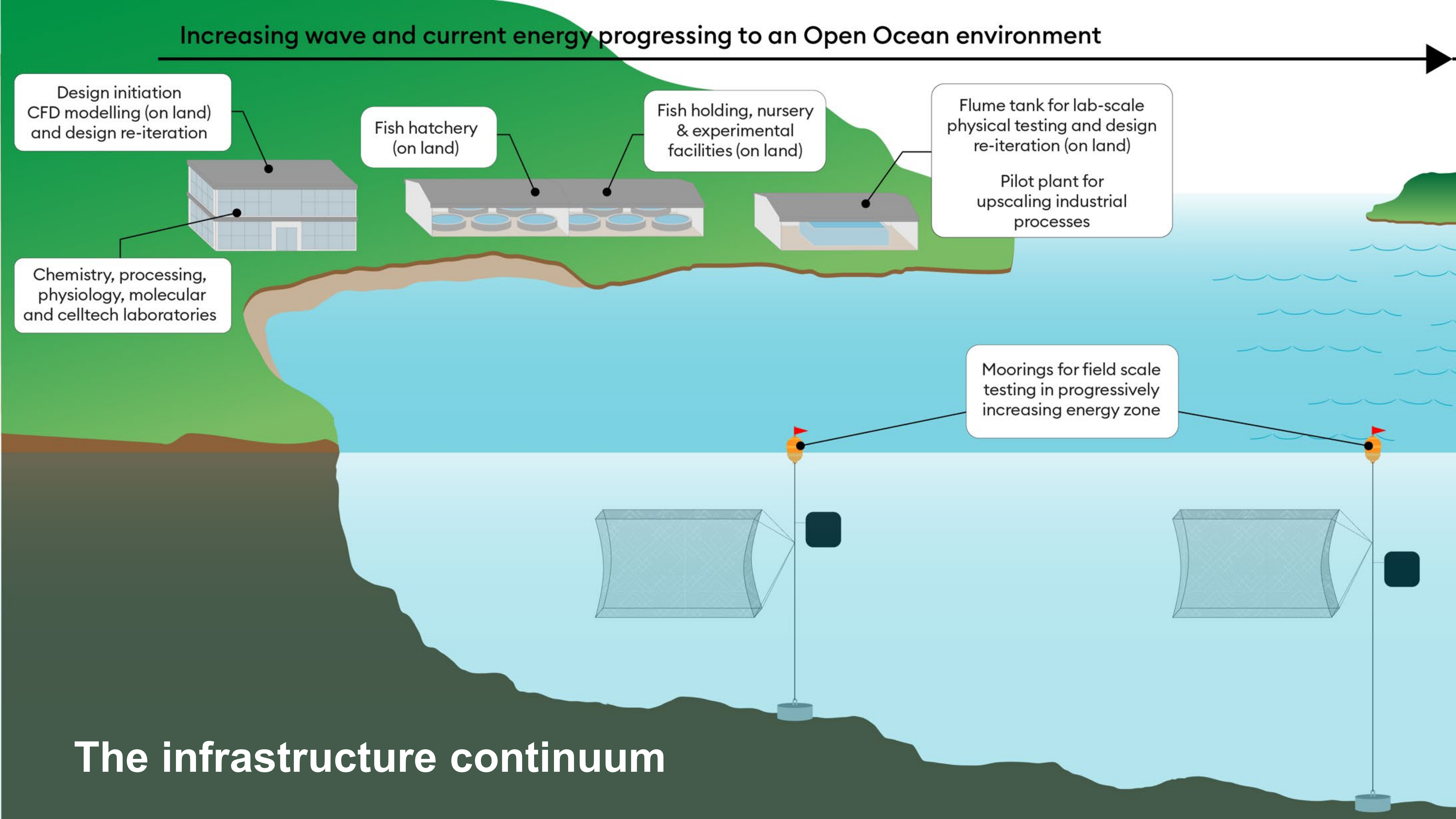
Susan Marshall

- Marine Biopolymer Science – Matthew Cumming
- Marine Product Chemistry – Daniel Killeen
- Marine Cellular Tech – Georgina Dowd
- Food Safety & Preservation – Graham Fletcher

Seafood Production Group

Maren Wellenreuther

- Physiology & Behaviour – Suzy Black
- Culture & Husbandry – Flavio Ribeiro
- Aquatic Design & Bioeng – Louise Kregting
- Phenomics & Genomics – TBC
- Aquaculture Ecosystems – Damian Moran


Increasing wave and current energy progressing to an Open Ocean environment
Design initiation CFD modelling (on land) and design re-iteration
Fish hatchery (on land)
Fish holding, nursery & experimental facilities (on land)
Flume tank for lab-scale physical testing and design re-iteration (on land)
Pilot plant for upscaling industrial processes
Chemistry, processing, physiology, molecular and celltech laboratories
Moorings for field scale testing in progressively increasing energy zone
The infrastructure continuum

D’Urville Island - resource consent application

- High delivery risk to MBIE programme (Re-imagining Aquaculture).
- High legal, financial and reputational risks associated with application for resource consent.
- Application through RMA can be time consuming.
- Fast track reduces time, legal & financial risks.
- Within existing consented space for mussels owned by Wakatū incorporation.
- Considerable consultation with Iwi & others.
- Will provide infrastructure that GF, SS & TD activity can utilise beyond the MBIE programme.

Proposed aquaculture consent- location detail

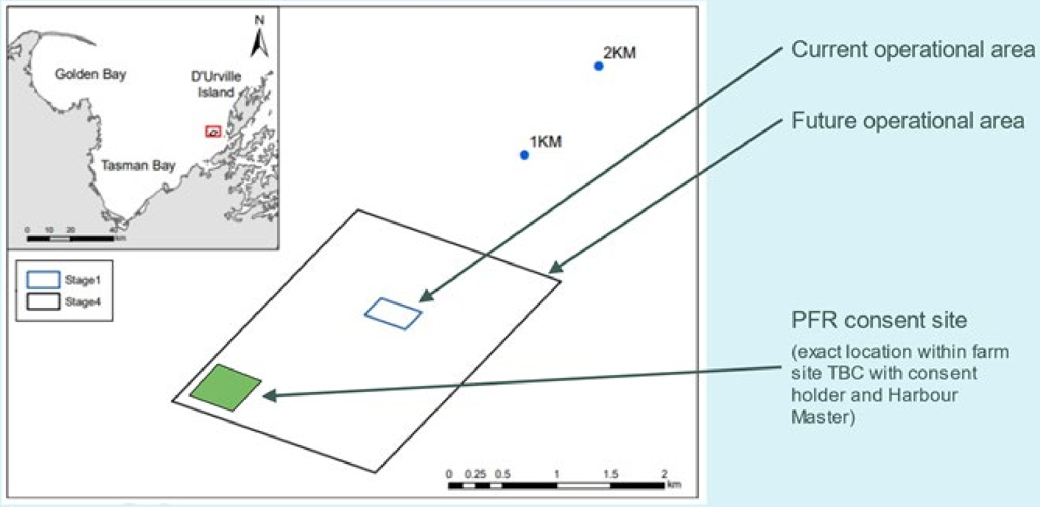
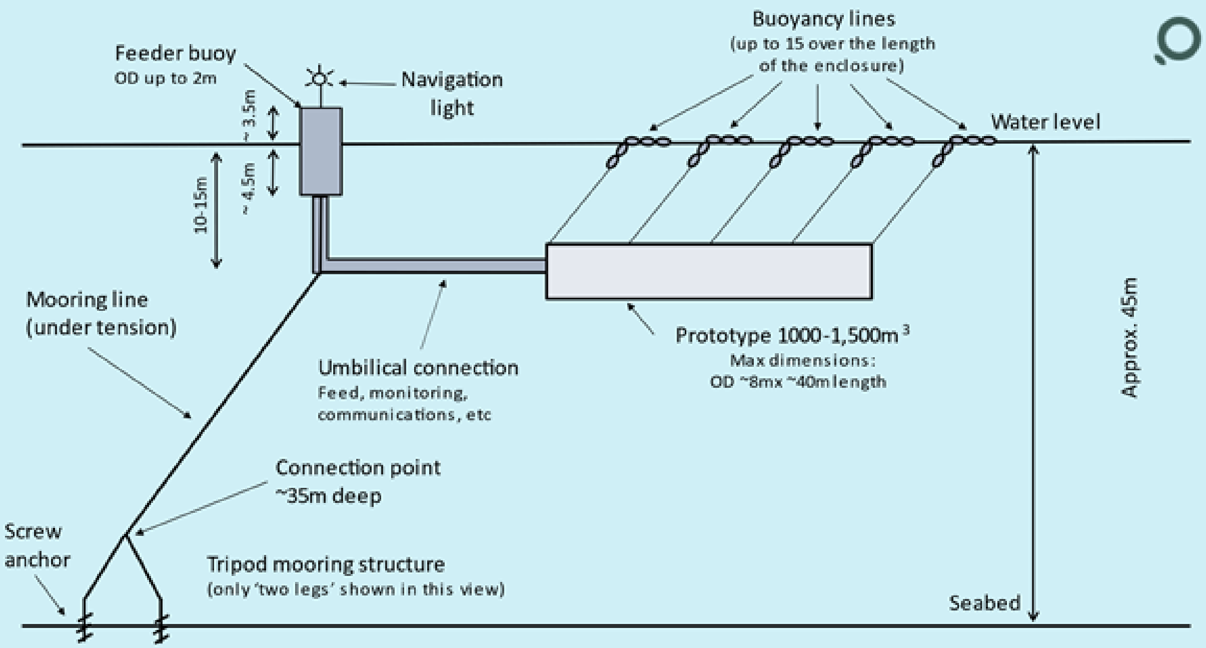


Figure courtesy ofCawthron Institute



PFR aligning with Māori

TONO PFR Māori strategy (2020–2030)

AN INVESTED ORGANISATION

CO-INNOVATION WITH MĀORI

ENABLING HUATAHI PARTNERSHIPS

Our vision

» Work together with Māori towards a future where Mātauranga Māori and science evolve research and innovation opportunities for Aotearoa-New Zealand

Our mission

» To be recognised as a **trusted research partner** by Māori. We **share in the benefits** from co-innovation in horticulture, seafood, plant and food research and **champion the value of indigenous knowledge** to the globe.

Stacey Whitiora
(Group General Manager Māori Strategy, Partnerships & Enterprise)
Ngāti Mahuta, Waikato

TONO GOALS & STRATEGIC PRIORITIES

Build staff understanding of Te Ao Māori

Grow the Māori talent pipeline

Celebrate Te Ao Māori in our work

Embed Tono in strategy, policy & process

AN INVEST
ORGANISAT

Build Mutual Capability with Māori

Deliver Māori Relevant Research

Alignment

Embed Taonga & Mātauranga Maori principles

An Equal Value Sharing Model

Pilot Fit for Purpose Partnership Agreements

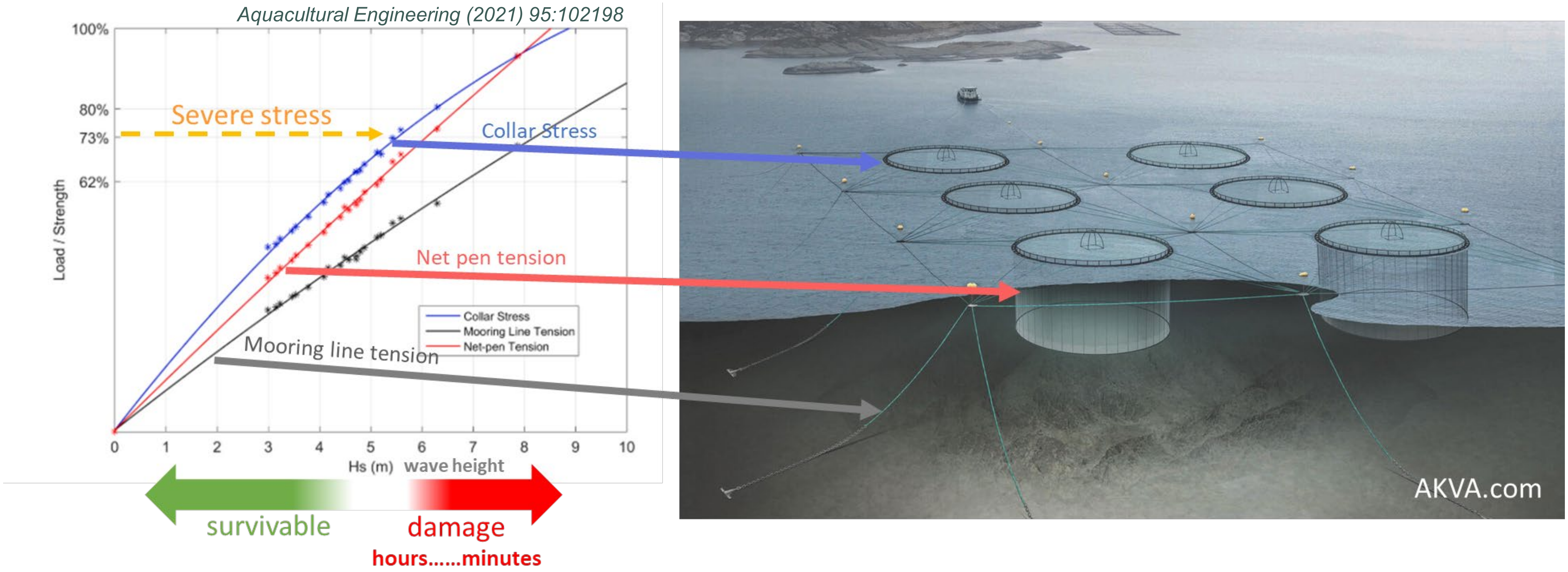
Māori Sector Growth & Insights

ENABLING HUATAHI PARTNERSHIPS

Te Rito Pathway
Under grad. summer internships → Masters and PHD positions ent

Open ocean aquaculture

What happens to a conventional sea pen in rough seas?



Primary failure is stress on the collar leading to buckling of the surface ring

Sea pen infrastructure is often damaged beyond repair


Aquacultural Engineering 95 (2021) 102198

Contents lists available at ScienceDirect

Aquacultural Engineering

journal homepage: www.elsevier.com/locate/aque

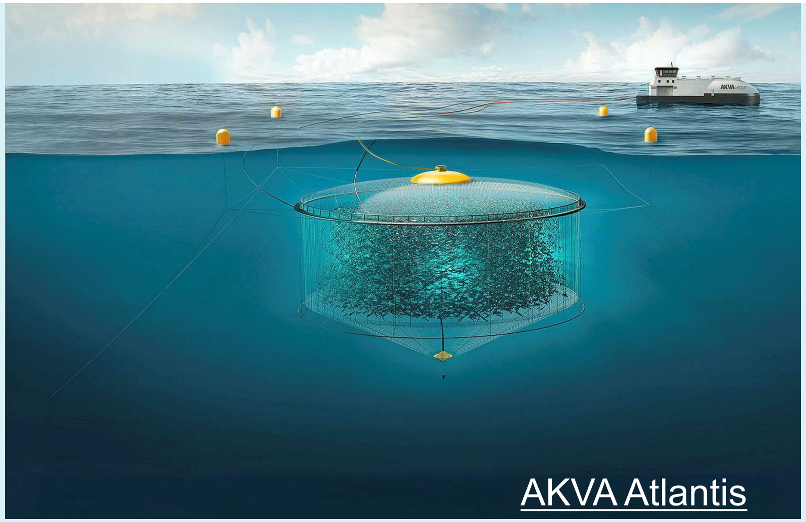
Storm damage risk assessment for offshore cage culture

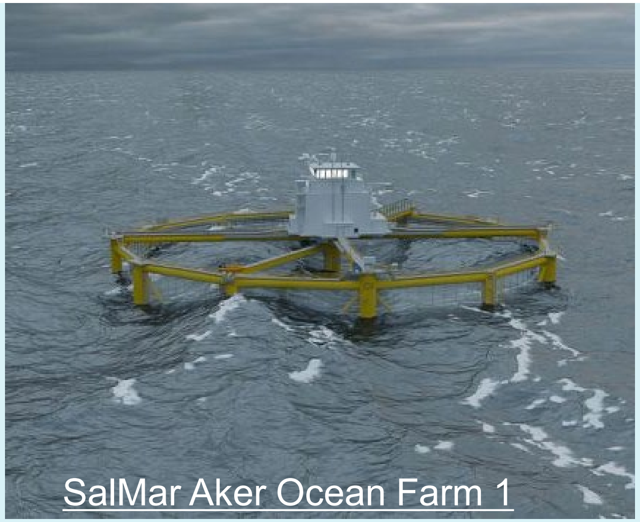
Yao Zhang[a], Jing Guo[b], Qiang Liu[a], Wanru Huang[a], Chunwei Bi[c], Yunpeng Zhao[c,d], Shanglu Li[b,*]

…and the fish stock can be lost

Fig. 1. Storm damage to sea cages at (a) North Carradale, Scotland in October 2020, © *BBC*; (b) Nanji Islands, China during Typhoon Lekima in August 2019; (c) Nova Scotia, Canada in January 2018, © *Responsible Aquaculture*; (d) Punta Islotes, Chile in May 2020, © *IntraFish*.

Submersible net pen options are coming online

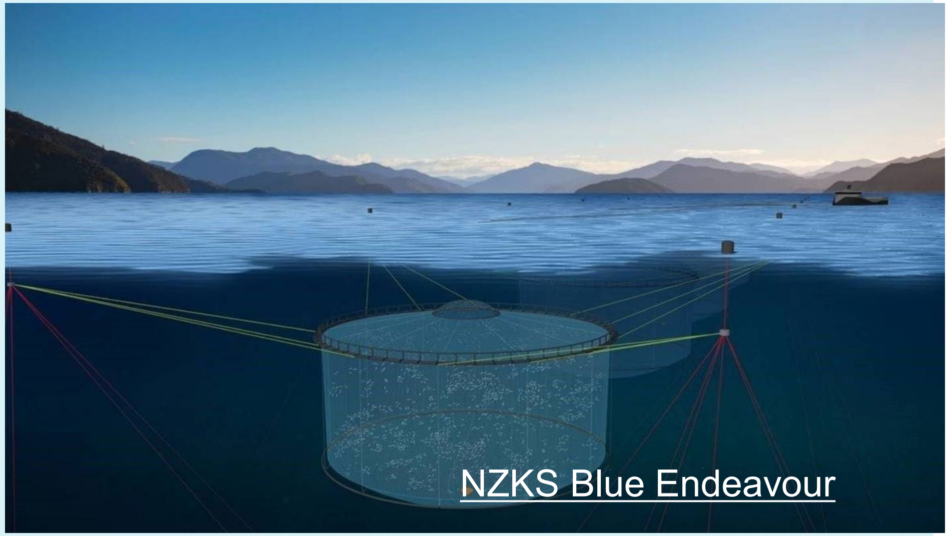

AKVA Atlantis


SalMar Aker Ocean Farm 1

InnovaSea SeaVolution

Qingdao Waysail Ocean Technology Co


Innovasea SeaStation

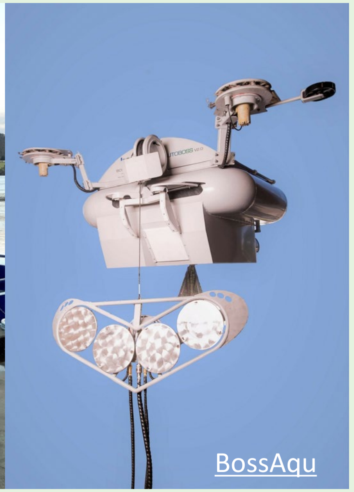

NZKS Blue Endeavour

Vessel operations are also affected by waves

Palfinger Marine

harvest (1-10 visits / year) & bathing (every 6-8 weeks)

AKVA net cleaning vessel



BossAqua

cleaning biofouling off nets (every 2-8 weeks)

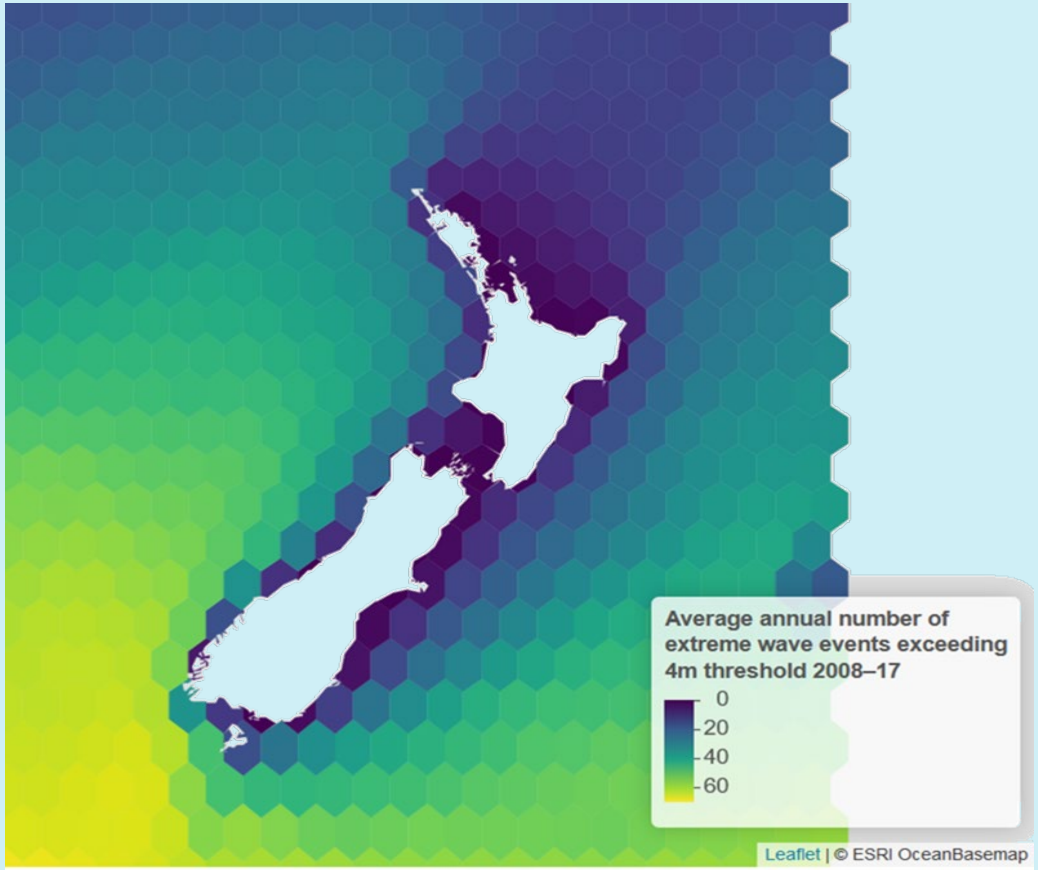
Sanford salmon feed barge

feed barges

SEA-A15 Aquaculture Support Hybrid Vessel

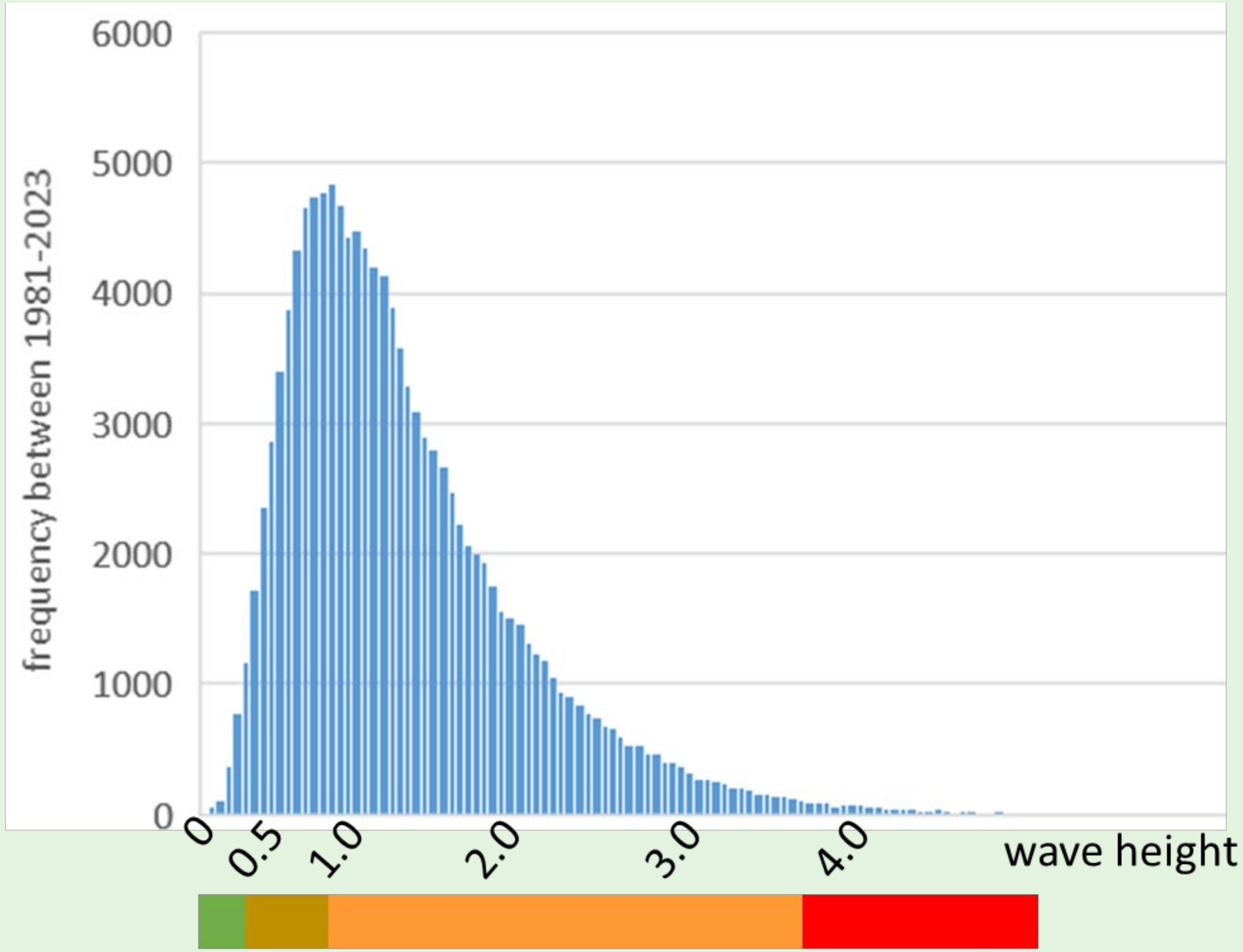
feed resupply, juvenile transport, work vessels

Where will open ocean aquaculture develop in Aotearoa?



- waves >4.5 m will damage or destroy conventional net pens in hours, >5.5 m in minutes
- the first regions to utilise open ocean aquaculture will likely be those with the lowest wave energy
- most exposed coasts endure a cage-wrecking storm (>5 m waves) every 1-2 years

Wave analysis of the Waiariki moana - Waihau Bay

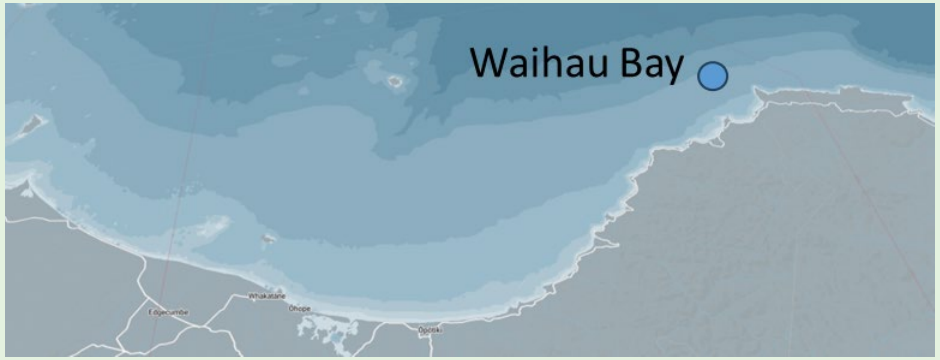


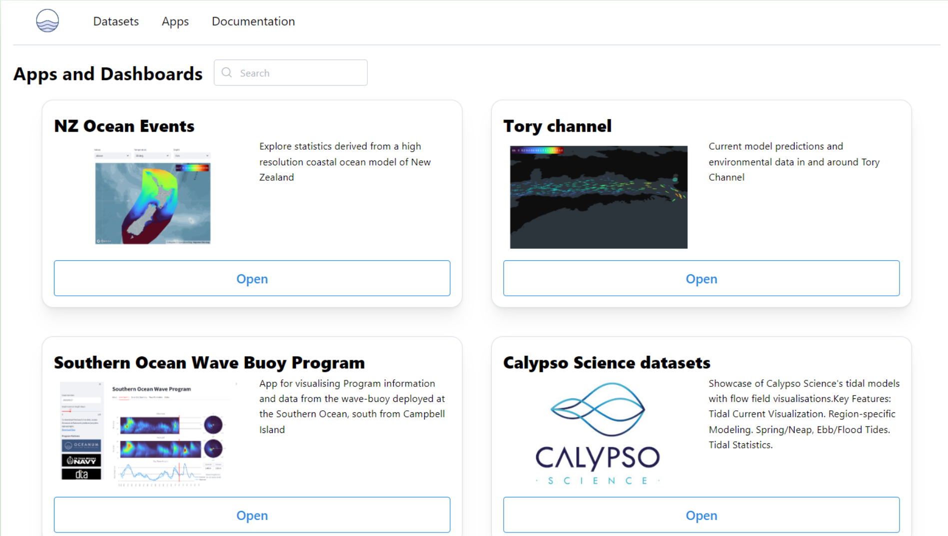
All husbandry operations OK

Feed resupply only

No vessel work, pen safe on surface

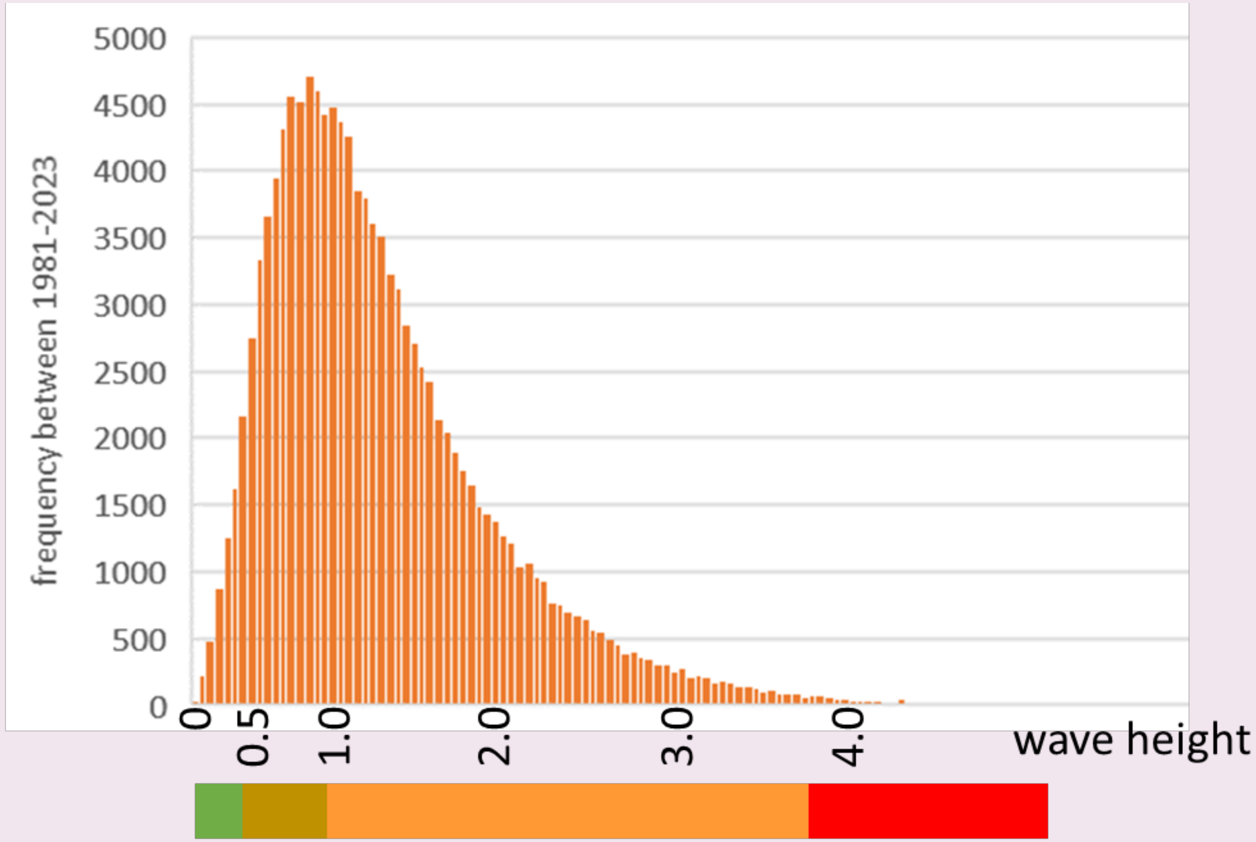
No vessel work, pen should submerge





Wave and water temperature data is freely available at oceanum.io

Wave analysis of the Waiariki moana – Ōpōtiki



All husbandry operations

Feed resupply only

No vessel work, pen safe on surface

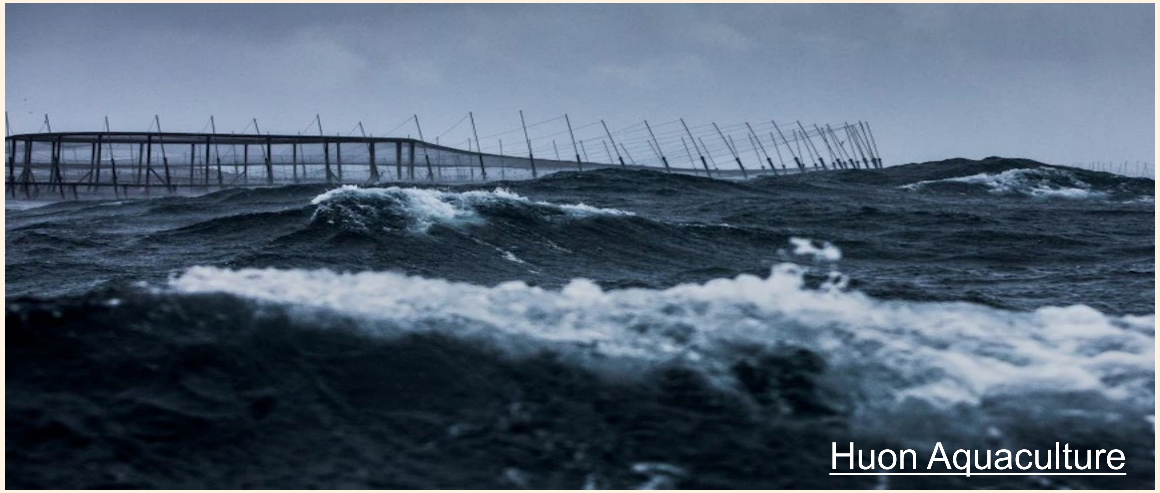
No vessel work, pen should submerge

Waves >5.5 m = 0.03% (event every 1-2 years)
Waves >4.5 m = 0.16% (5 days a year)
Waves <1.0 m = 40.7% (149 days a year)
Waves <0.5 m = 5.38% (20 days a year)

Open ocean fish farming considerations for Waiariki

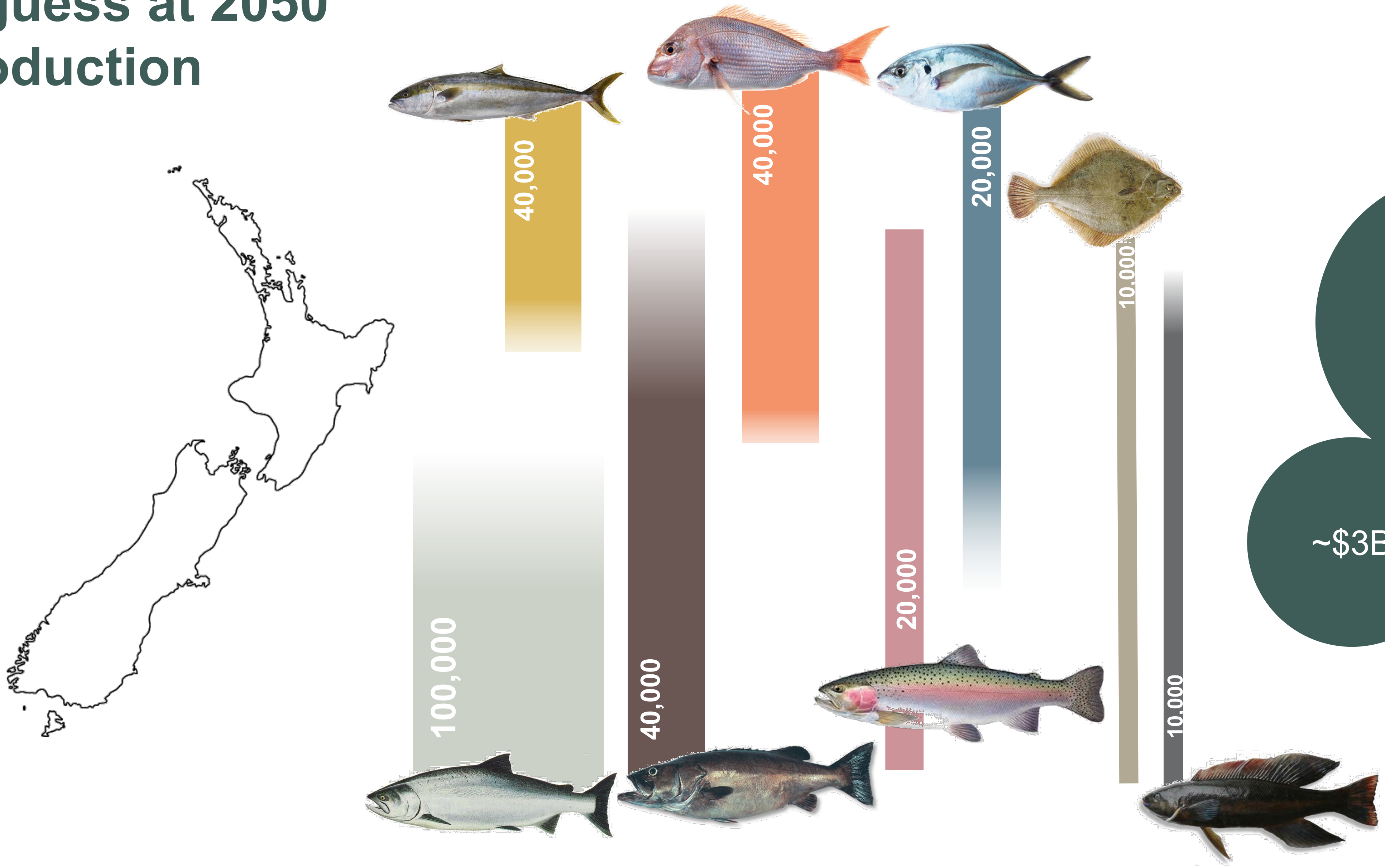
- » There is probably good enough submersible cage options available to dodge the very large waves
- » The main challenge will be operating and maintaining fish at the site
- » Innovative logistics model the key to success

- » Vessel service work needs <1 m swell
- » Waves <1.0 m = 41% (149 days/year)
  - » Daylight work = 8 h per 24 h (33% of day)
  - » 33% x 149 days/year = 49 days/year = 1 day/week operating window


Huon Aquaculture

Huon Aquaculture

A guess at 2050 production



280,000
MT/year

~$3B

…based on species mix in other countries and the size of markets.

Mobile production systems

OOA: Mobile Aquaculture Production System – MAPS

MBIE Endeavour Fund Programme:
Whakapōhewa ki ahumoana Re-imagining Aquaculture

Objective: *to take seafood production beyond wild capture and traditional static intensive aquaculture into a new era of mobile production systems*

- Flexible, mobile and readily tuneable
  - Not limited by site-specific environmental fluctuations and water quality
- Designed to meet the biological needs of the fish
  - What do fish prefer? What is optimal?
  - Production of high-welfare, healthy, resilient fish
  - Lightest environment footprint

Mobile Production – The "Pacific Way" for open ocean aquaculture

Specifically designed to support biological needs of fish

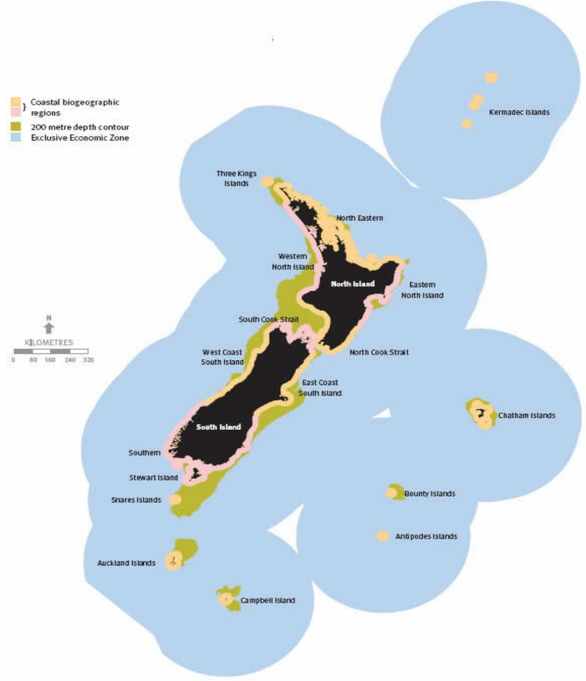
- With improved growth, temperature conditions, flow, health and welfare

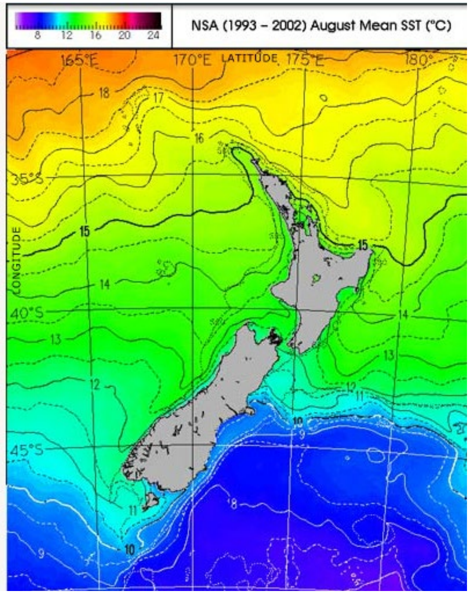
Plays to New Zealand's strengths

- Utilises New Zealand geography & oceanography, and large EEZ

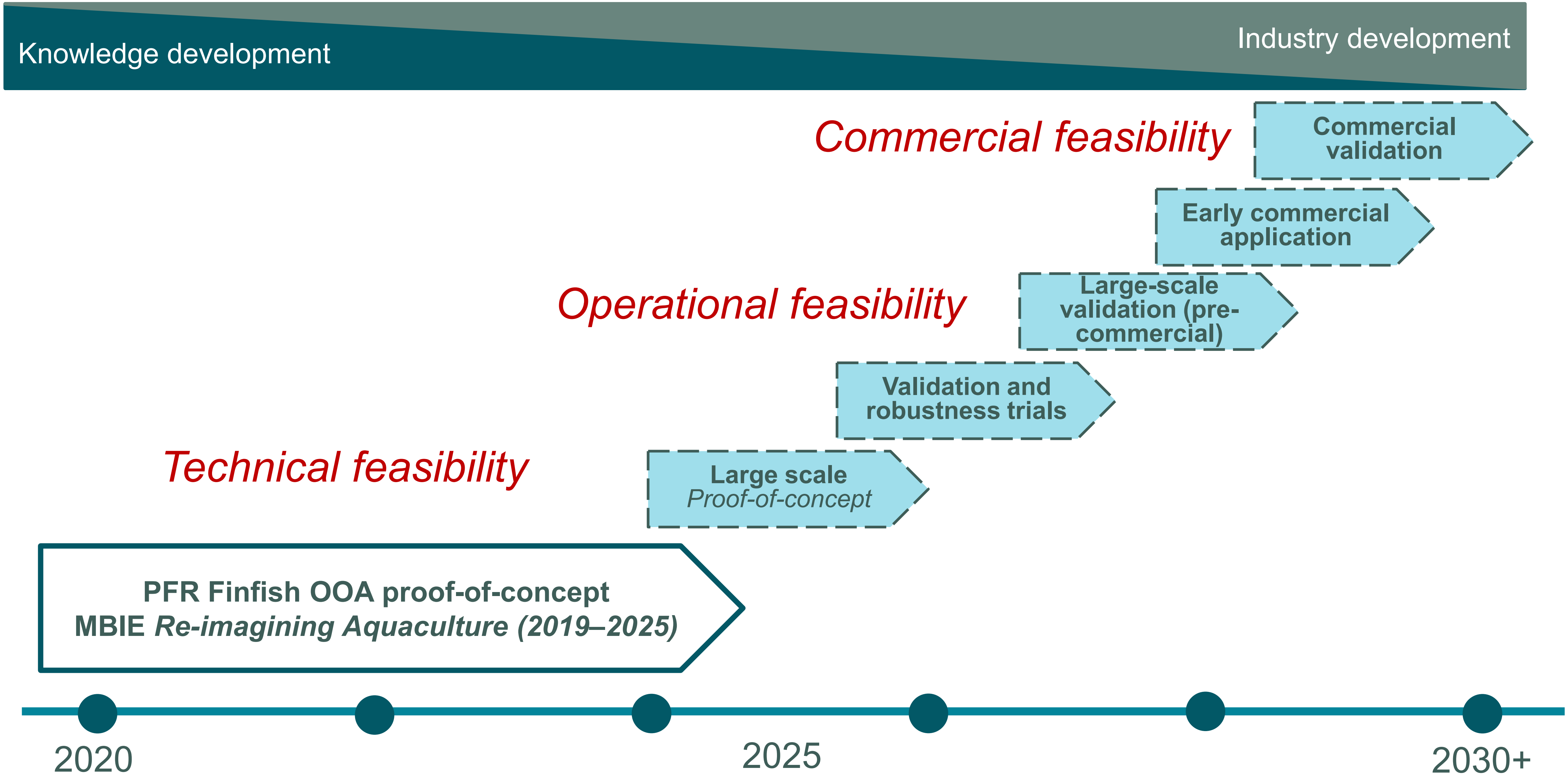
Alleviates existing issues

- Social licence – coastal occupation
- Environmental footprints – e.g. waste, benthic impact.
- Biological – optimal conditions year-round
- Resilience – climate change, species diversification





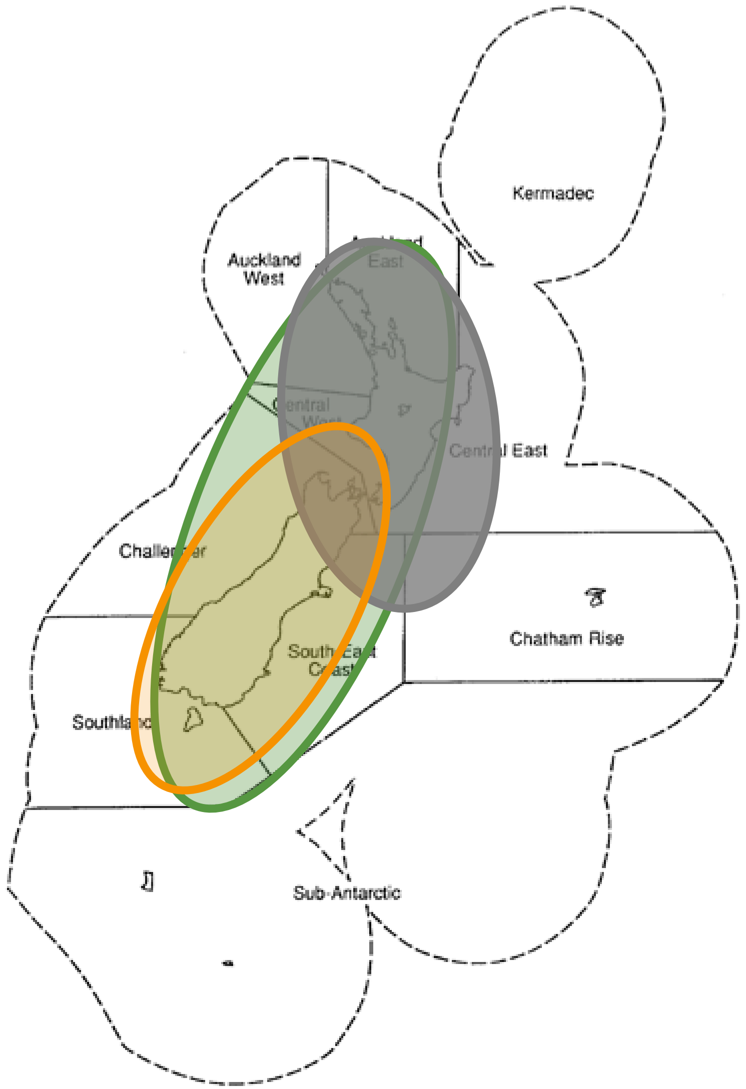
Key steps towards operational finfish OOA



Breeding native finfish species

Aquaculture is an integral part of sustainable food production in Aotearoa

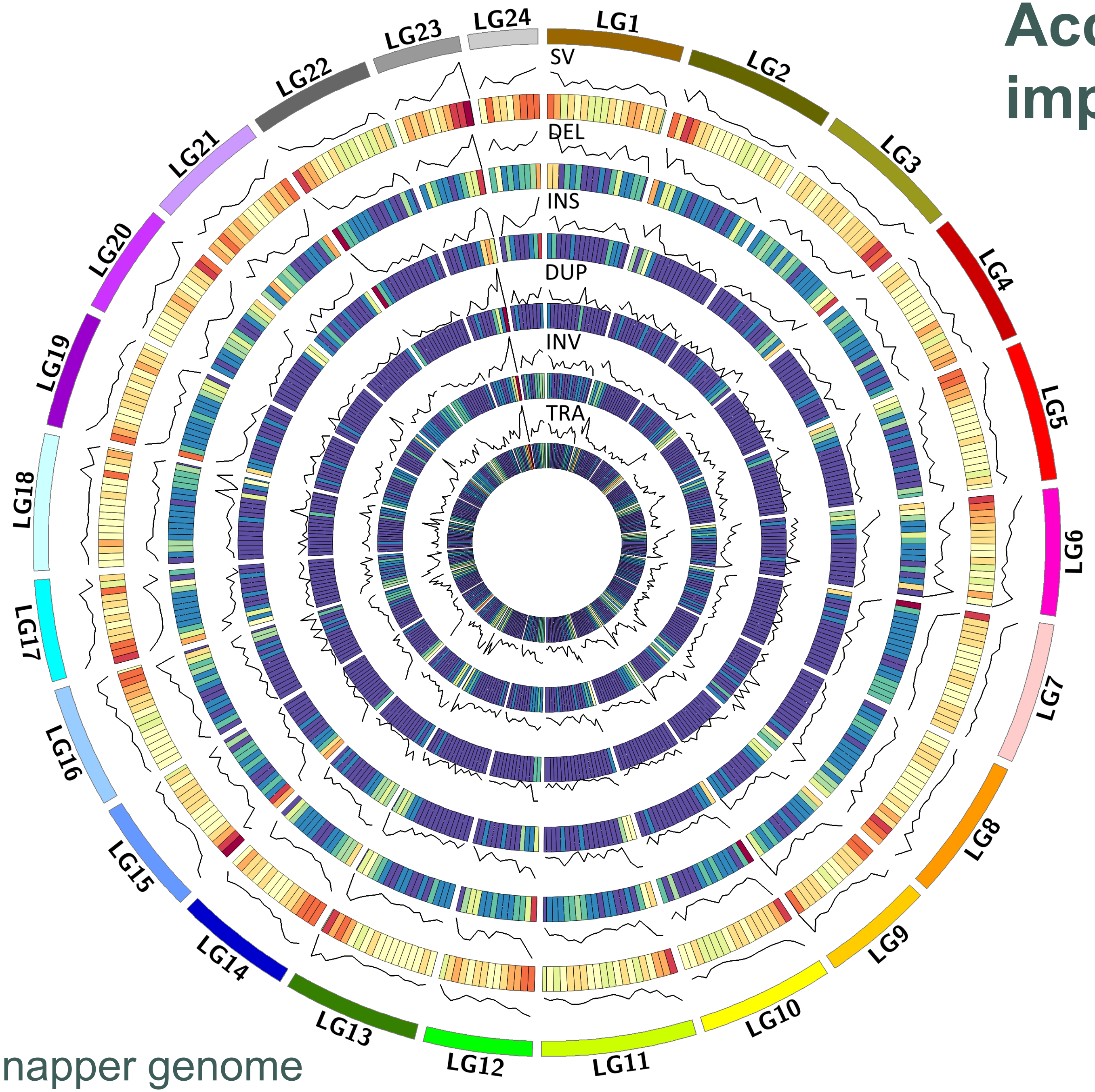
- We have the 5th largest EEZ (roughly 430 million hectares) in the world, about 15 times the size of our land mass
- Lack of species diversity, and growing space, limits production
- Tio (Pacific oysters), kuku or kūtai (greenshell mussels), and Chinook salmon



PFR has extensive expertise in new species development

- We have bred: trevally, blue cod, yellowbelly flounder, tarakihi and snapper
- Tāmure/Snapper has emerged as a promising candidate for aquaculture
- We have produced elite (4th generation) snapper:
  - 30-45% faster growth
  - Improved survival
  - Improved FCR

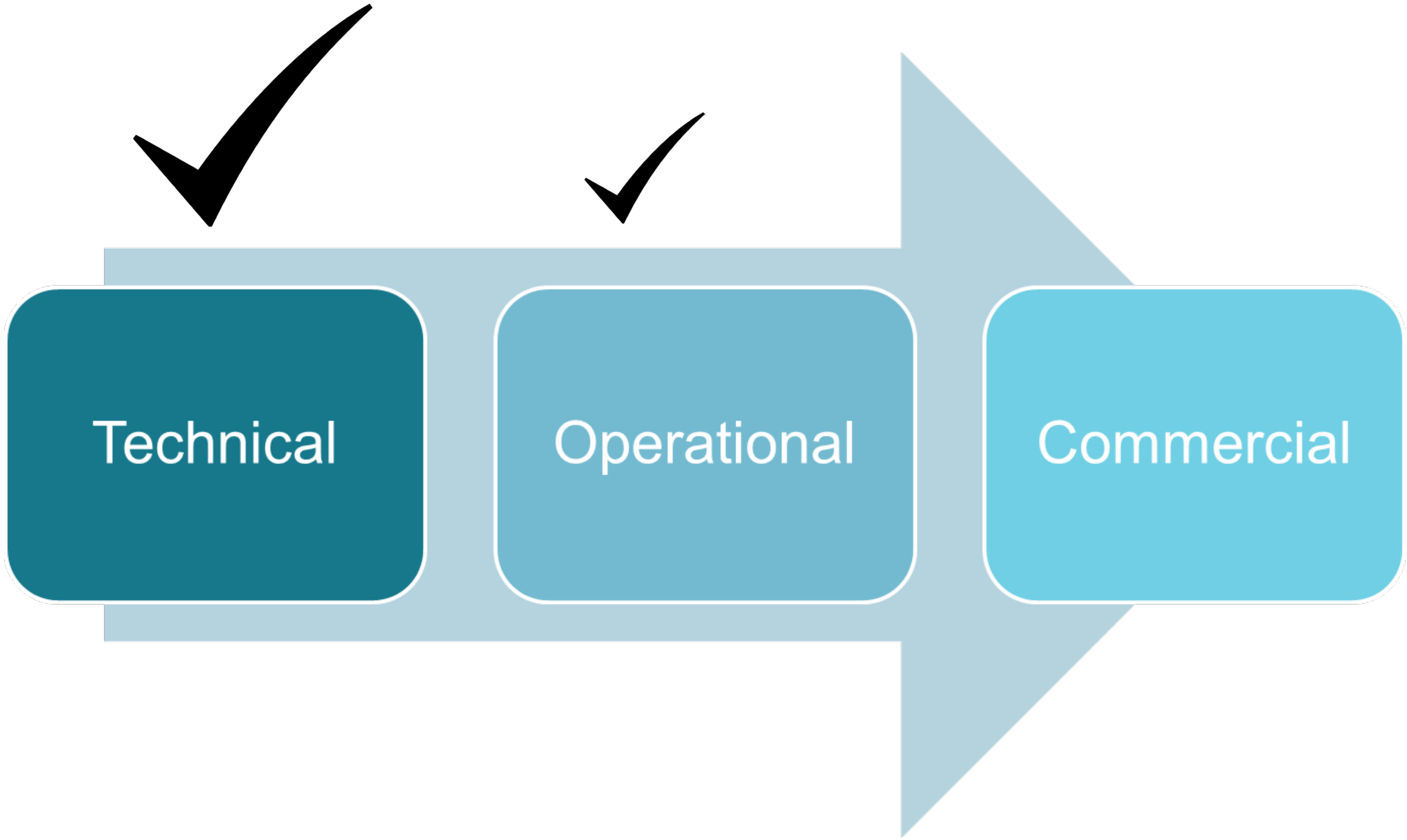
Accelerated breeding improvements



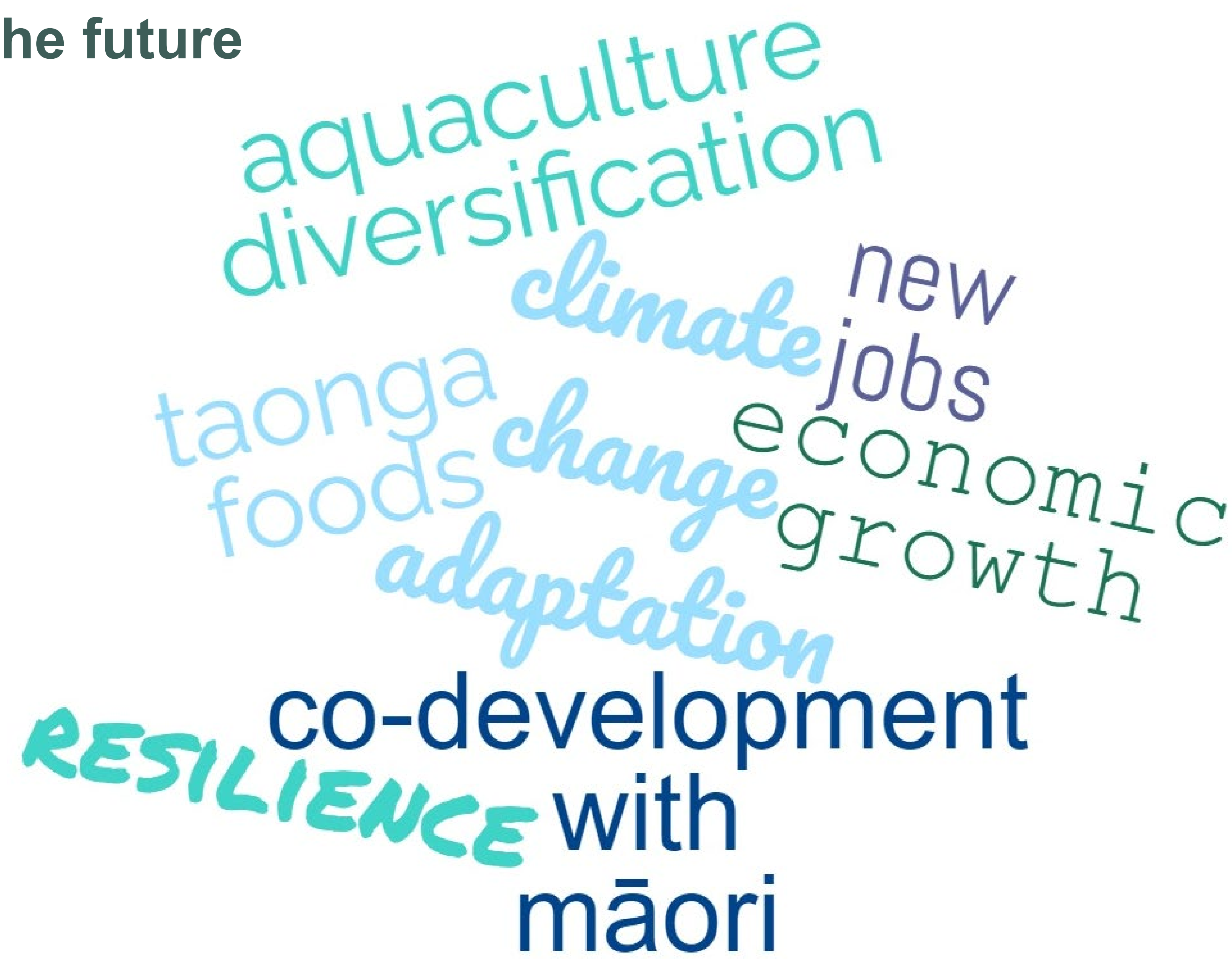
Snapper genome

- PFR holds the elite genetic lines in Nelson
- We have deep knowledge about the genomic regions underpinning growth and other traits
- We understand how to spawn broodstock and rear larvae
- We have operational know-how about the production cycle from 3 months to harvest size in a seapen

Co-developing commercial aquaculture opportunities with iwi in the Marlborough Sounds and beyond



Our vision for the future



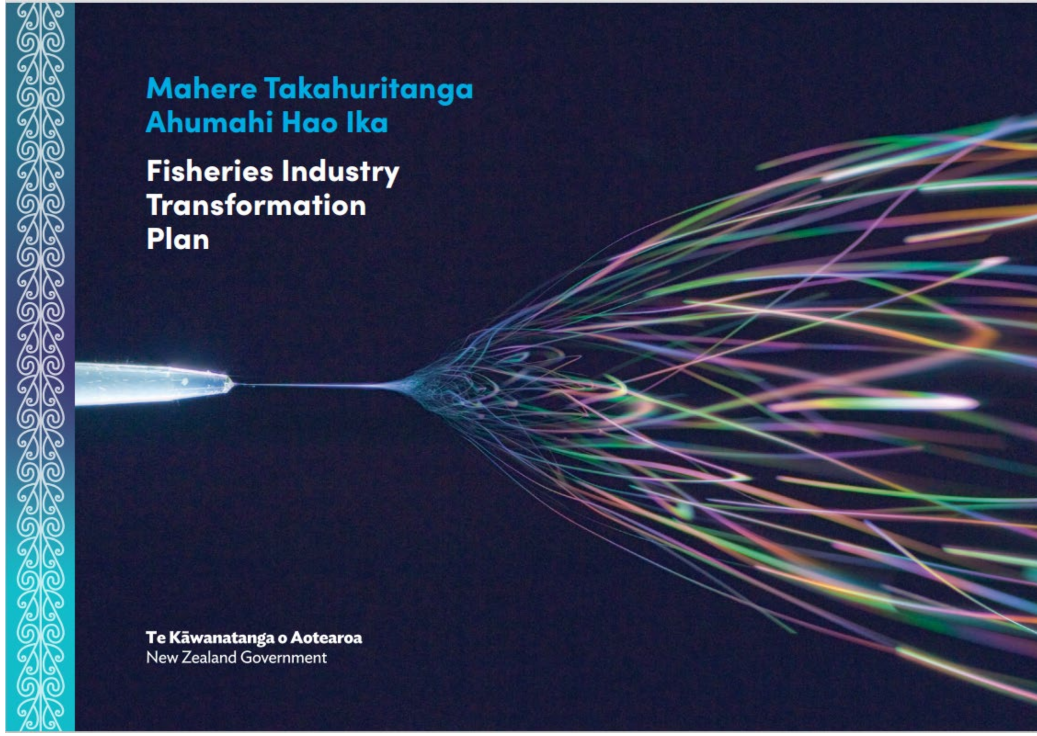
Optimised utilisation of marine biomass

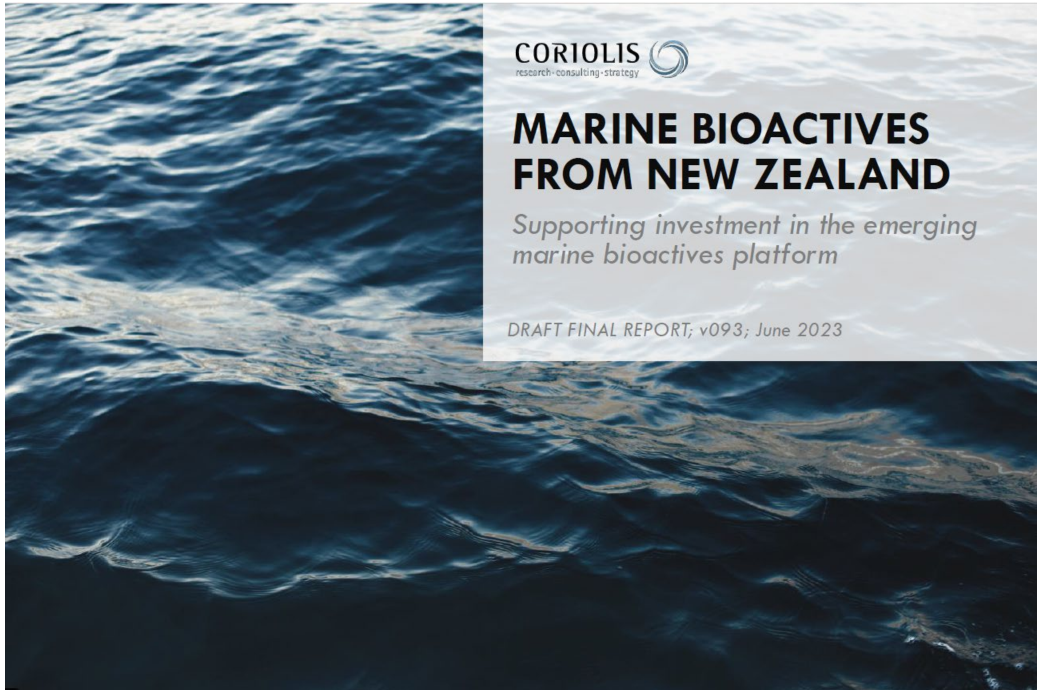
Seafood Biorefineries for Aotearoa

- Most value from every kg raw material
- Multiple products: efficient factories
- Suite of processes applicable to any species/raw material
  - Processes safe for people and environment
  - No waste/effluents
  - ↓ energy
  - ↓ water use
- Automation
- Products
  - Existing & new
  - Fully characterised

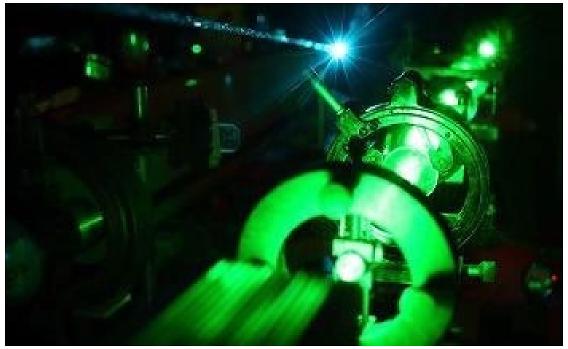
Right time

- MBIE funding (Cyber-Marine)
- Bioresource Processing Alliance (BPA)
- Best team
  - PFR
  - Callaghan Innovation
  - University of Otago
  - Victoria University of Wellington
  - Deakin University (Australia)
- Equipment (Lab and pilot)
- Sector support
- Government support
- Fit to PFR research theme “100% utilisation”





Approach: idea to product (& everything in between)

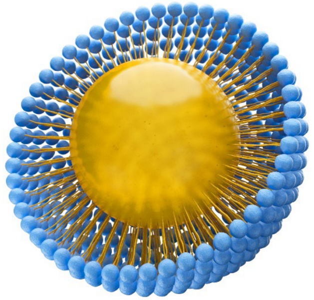


Analysis

- Chemical
- Functional
- Lab & in-process
- Spectroscopy
- Microbiology

Green process technologies

- New processes
- Multi-product cascades
- Low energy, low carbon
- Full component recovery
- Automation/AI

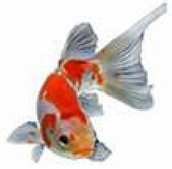


Novel new products

- Fractionation
- Synthesis
- Composites
- Biomaterials

Prototyping

- Pilot plant
- Commercial
- (Trouble shooting)



Cyber-Marine

What's in there?

- Wet chemistry (slow)
- Laser spectroscopy (fast) INCLUDING PORTABLE
- AI for instant analysis
- Should we harvest?
- What processing path gives best value for <u>this</u> raw material?

How do we get it all out? What can we do with it?

- New technologies for lipid extraction
- Efficient multi-product cascades
- Processing choices to match with composition, desired products, and equipment
- New extracted products
- New modified products with different properties
- What do markets want?

What then?

- Prototyping and scale-up
- Technoeconomic modelling

Unfilleted Finfish (Jack mackerel)

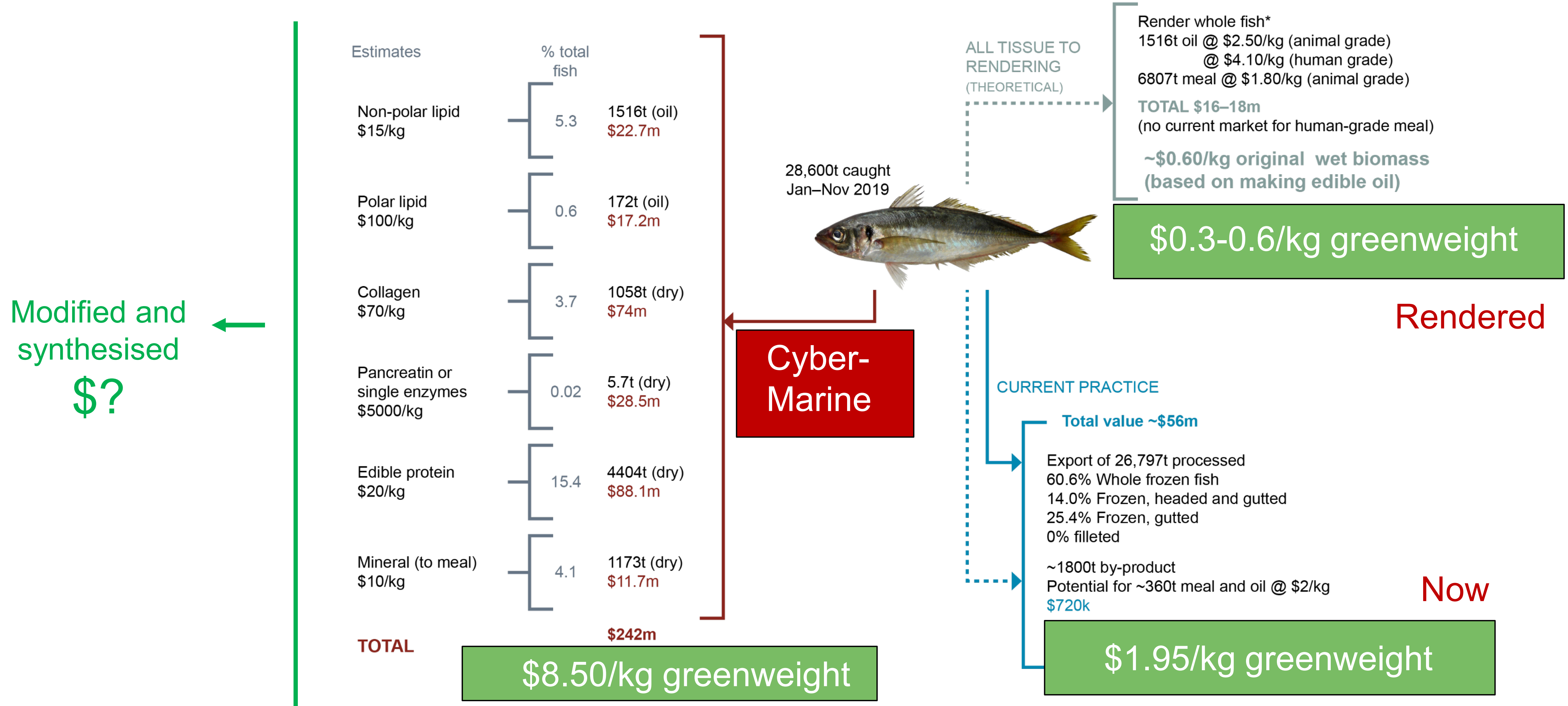


Figure 5. Options and export returns for processing of Jack mackerel based on catch data Jan-Nov 2019 (Seafood NZ Export Data) and tissue composition (PFR in-house, Vleig 1988). *Rendering values are from Talley's Jan 2020 (pers. comm.)

GSM: What's happening now? (2019) ~100,000t

$356 M
$317 M food, $39 M other

93% harvest

Food
$317 M
$8/kg

Waste: contains protein and minerals

WASTE SHELL

7% harvest

Powder

- -ve $ & reputation: impact whole powder market
- Contains all valuable phospholipids ($\geq$$2000/kg)
- Lots of protein
- More minerals

Powder
$4.2 M
@$65/kg

Supercritical Extraction

SCO_2 technology extracts <50% oil

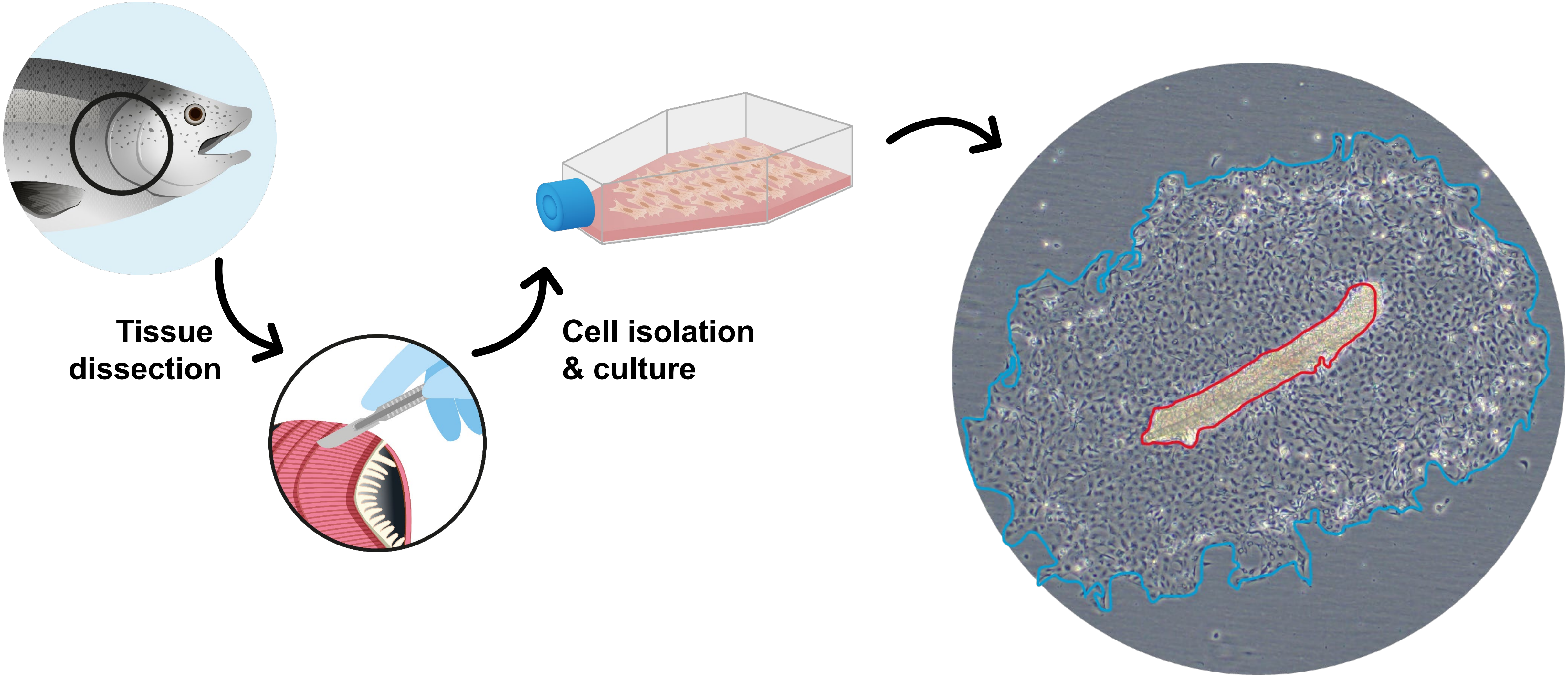
Oil
$26 M
@$2000/kg

Defatted powder
$8 M
@$23/kg

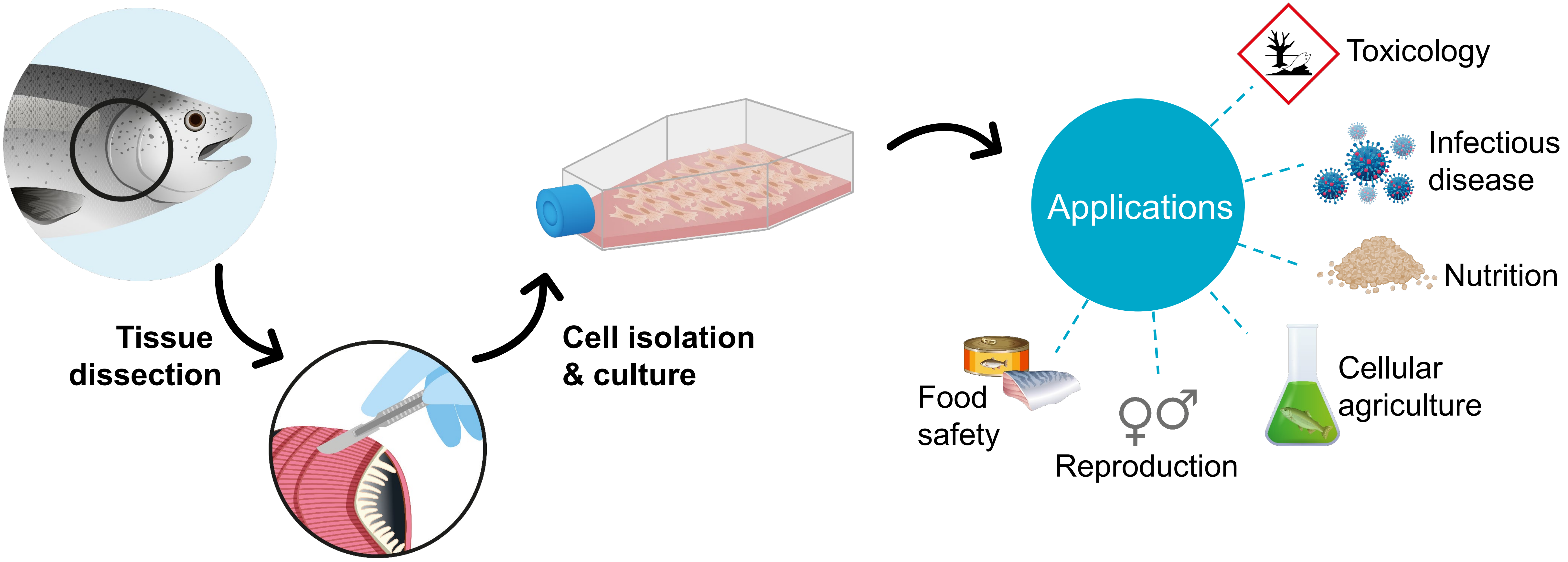
$421 M
$317 M food, $104 M other
(PL, proteins/peptides & minerals)

Cellular technologies in seafood

Marine Cell Technologies



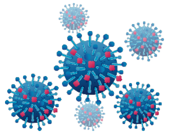
Marine Cell Technologies



Applications

Toxicology

- *Chemicals, water, environmental and tissue samples*
- *Aquatic pollutants*
- *Algal toxins*

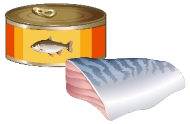


Infectious disease

- *Viral disease*
- *Bacterial disease*
- *Water moulds*
- *Hosts immune response*
- *Vaccine development*

Cellular agriculture

- *Cell-based seafood*
- *Cell-derived products*



Food safety

- *Zoonotic disease*
- *Transboundary movement*

♀♂

Reproduction

- *Primordial germ cells*
- *Transplantation/surrogacy*
- *Conservation/frozen zoo's*

Nutrition

- *Nutrient absorption*
- *Metabolism*
- *Macro/micro-nutrients*

Why?

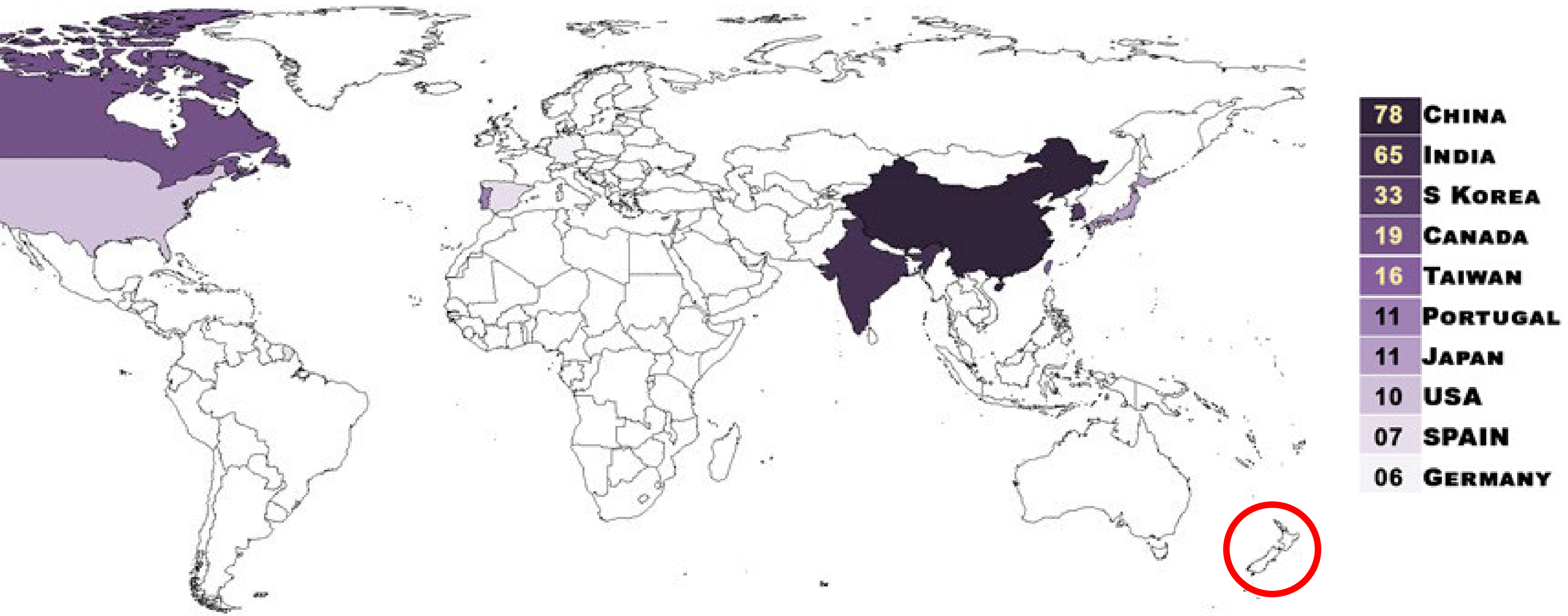
Species specificity

Global context

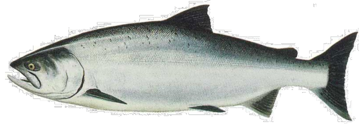
2010-2020

Cyprinids

Salmonids



Just 2% of all fish species
are represented



Chinook salmon

Snapper

Trevally

Kingfish

Why?

- Species specificity
- Rapid response
- Reduced cost
- Throughput
- Multi-factorial analysis
- Biological replication
- Ethical

Plant & Food™
Research
Rangahau Ahumāra Kai

Thank you

plantandfood.co.nz

A smart green future. Together.