Transfor Transforming Bulk Seafood Harvesting by producing the Most Authentic Wild Fish

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Precision Seafood Harvesting

A PSH caught gurnard.

In Brief

The Primary Growth Partnership ended in March 2019 having achieved much. Key concepts and 6 project workstream results are summarised and further papers will cover technical and policy/regulatory developments. The gear will be commercially available worldwide in 2022 and be underpinned by this independently peer reviewed information.

Key Concepts

- Well-managed fisheries increase value through improving productivity, quality and efficiency rather than increasing volume. From being a frozen, commodity fishery, the New Zealand Hoki fishery has learnt how to preserve inherent, natural qualities.

- Trawling is economically efficient bulk fish harvesting and has relied upon collecting exhausted fish in the cod-end. Fish are physically damaged and highly exercised i.e. every uncontrolled interaction is a potential deficit.

- New Zealand fish physiology scientists collaborated with leading seafood companies and the government in the Precision Seafood Harvesting (PSH) Primary Growth Partnership (PGP) to develop technologies to harvest key commercial fish species in minimally damaged, minimally fatigued condition to enable the quality potential to be realised for rested harvested fish.

- They envisaged and developed a modular harvest system (MHS) to match the internal waterflow velocity with key species' swimming speed. MHS fish could surface alive, neither injured nor stressed and smaller fish and unwanted species, including megafauna, could escape or be released and survive. Being rested, the muscle/raw protein material quality is significantly improved which dramatically increases higher value product options.

- This MHS is in commercial operation in New Zealand deepwater fisheries and under trial in inshore fisheries.

- It could significantly transform bulk harvest fisheries worldwide.

Precision Seafood Harvesting was catalysed by two scientists in 2005 noticing in video footage of inside a fishing net, that there was a low velocity waterflow zone just in front of the cod-end where Hoki, an important commercial fish species, were swimming easily. These fish physiologists from the Plant and Food Research (PFR) Seafood Group had spent a decade researching how to minimise fish stress by understanding which harvesting conditions did not match target fish species physiological limitations. They then handline caught Hoki to better understand its more natural attributes i.e. When brought up from approximately 200m, Hoki is iridescently coloured with translucent flesh, along with other attributes of minimally fatigued fish – in stark contrast to conventionally trawled Hoki with

poorer condition through for example scale loss. They realised the enormous innovation potential to revolutionise New Zealand's biggest fishery, and potentially transform bulk harvest fishing globally. New Zealand has small fisheries by volume yet is a significant political player in fisheries management and seafood business globally. It had the earliest, most comprehensive fisheries management reform in introducing the Quota Management System (QMS) in 1986 and creating the Māori Fisheries Settlement called The Sealord Deal in 1992. More than 130 different fish species are caught commercially with a focus on about twelve. Eight are wild-caught finfish and arrow squid. All of these have the potential to be improved through Precision Seafood Harvesting (PSH). Seafood companies Sealord Group, Moana New Zealand and Sanford co-invested with the New Zealand Government (Ministry for Primary Industries, MPI). PFR provided the technical services to develop the designs and specifications to create the Modular Harvest System (MHS) in this 7-year, $43 million project focussed on Hoki, Snapper and Arrow Squid. These represent key species sought commercially and all had significant value improvement potential. Together, these fishing companies hold 30 to 60% of the nine top species quotas, fished in New Zealand waters. Moana New Zealand is owned by the Māori people of New Zealand and owns 50% of Sealord Group, along with Nissui. New Zealand's largest seafood company, Sanford Ltd is publicly listed. These partners are committed to finding ways to sustain the natural resource that their enterprises, and much of New Zealand's marine economy, rely on, through designing new harvesting and handling technologies and new branding and product development to can create new, high value seafood products to be marketed to increasingly discerning customers.

The primary challenge was to embrace innovation, create momentum and shift the seafood industry from a quantity to a quality mindset in the trawler fleet[1]. The PSH programme occurred alongside industry commitment to fishing fleet modernisation. The sustainable management of New Zealand's fisheries is overseen by Fisheries New Zealand, now part of MPI. Under the QMS, allowable catches are unlikely to increase significantly in the future using current fishing methods, so increasing value will come from improved quality. In parallel, harvesting practices must ensure that the fisheries resource is maintained, or better grows, into the future, and that ecological and environmental impacts continually reduce. The PGP intent was that harvesting precision would come from using modular trawl systems with components customised for vessel and target species, to deliver high quality fish on board through giving the operator control over the species and sizes of fish that are landed.

Catalysing Innovation

The Company Goals

Moana New Zealand

- Improve inshore trawled fish quality so as to enter new markets and achieve price premiums.
- Enable more sustainable ways to harvest fish through the Precision Seafood Harvest modular system.
- Better understanding and control of the trawl footprint of our fishers.

Sanford

- Enhance the Sanford brand with sustainable, innovative fishing techniques.
- Improve returns from existing assets, aquaculture and fishing operations.
- Realise seafood market opportunities through improved product quality and consistency.

Sealord

- Transform its core New Zealand fishing business.
- Develop new fish species, both wild catch and farmed.
- Grow Australasian marketing.

People drive change and are motivated by negatives (e.g. fear, shame, financial loss) or positives (e.g. love, respect, fame, passion, glory and/or financial gain). Significant paradigm shifts often arise from aspects of both occurring in tandem.

Internal

New Zealand's deepwater industry prides itself on the QMS's control of commercial catch and was recognised as the first Marine Stewardship Council certified trawl fishery globally. This brought many benefits including fostering a continuous improvement culture. Industry has continued to address issues such as Hoki pinking and blood spots, fleet modernisation, decommodification, improving efficiency and value, reducing environmental impacts and rationalising research. Sanford operates in both inshore and deepwater fisheries whilst Moana New Zealand focusses on the inshore where key issues include aging vessels and skippers, challenges finding and keeping crew, spatial pressure from recreational fishing and for marine protection, and declining marine ecosystem health due to, for example, sedimentation and climate change. Sealord Ltd is a major deepwater company 50% owned by Moana New Zealand. Both Sanford and Moana New Zealand have explicit corporate sustainability journeys alongside the PSH PGP programme.

External

Bulk harvest seafood production marine ecosystem effects have been a noted concern since the famous 1866 bottom trawling British Royal Commission. The New Zealand Seafood industry recognises that bottom trawled seafood is contentious. There are divergent views on the 74% by volume of New Zealand deepwater species that are Marine Stewardship Council certified as well as more broadly on New Zealand fisheries management, operational practices and spatial management i.e. the Benthic Protected Areas (BPAs). These are where the fishing industry proposed, and Government implemented, closing large areas of New Zealand's Exclusive Economic Zone (EEZ) to protect the seabed from trawling in 2007. The New Zealand Government and seafood sector state that the BPAs protect the benthic biodiversity of approximately 30% of the EEZ, many of the known seamounts, and active hydrothermal vents, and that they deliver on the Aichi Convention on Biodiversity Marine Protected Area (MPA) targets. Many conservation advocates disagree, noting the BPAs do not constitute a comprehensive, adequate or representative network of MPAs, and do not protect either the water column above, or the substrate, and so are at risk, for example from mining[2].

Genuine Intent

The proportional nature of the QMS encouraged industry players in their understanding of:

- the importance of culture change from frontier/hunter gatherer to resource stewardship,
- the importance of improving environmental performance themselves to protect their economic sustainability and to improve public perception, and;
- the latent growth opportunity in the negative impacts of the then trawling methods.

Another factor in driving forward the PSH PGP programme is that two of the three commercial partners also have Māori ownership with inherent deep commitment to kaitiakitanga (stewardship).

The Primary Growth Partnership

New Zealand is a relatively young country with a low population and significant natural capital. It has long been a food basket for the world. As the nation has realised the limits of the impacts on natural capital, significant resource management innovation occurred in creating the Resource Management (1991) and Fisheries Acts (1983 and 1996). In 2008 the Labour Government established the Fast Forward Fund[3] to encourage primary

industries into higher value primary industries. The National Government reformed this into the PGP in 2009 to increase primary sector investment in innovation, economic growth and sustainability by encouraging vertical integration and horizontal collaboration and to meet increasingly discerning customer requirements. Then Minister of Agriculture and Minister for Biosecurity, the Hon. David Carter noted:

> *"A real feature is how it has been closely developed with industry. It is unashamedly industry-led and simple in its structure."*[4]

MPI is the New Zealand Government's PGP programme partner and manages, co-invests in, regulates and monitors the participating sectors. MPI considered the PGP programme to be important to achieve the then Government's Business Growth agenda (June 2012) goal to double primary industry export value by 2025 and encourage more private investment in research and development. Its innovation origins and new collaboration/quasi-independent structures resulted in MPI being extremely cautious and requiring exacting performance measures of the PSH PGP programme. A 2015 Office of the Auditor General (OAG) report noted that the "PGP was set up quickly but was not always smooth."[4] It noted that, at the time of the review, the PGP partnerships were working well and management had improved over the five years it had been operating. Three recommendations for improvements were provided that were subsequently adopted.[5]

Collaboration

In fisheries, generating true commitment to collective goals among common pool resource users is difficult under normal circumstances. The QMS brings secure resource access and quota owners are incentivised to collaborate with government in management processes. This led the co-investors to co-operatively commission this research and overcome a major fisheries research barrier, the access to commercial fishing vessels. This seafood research and development alliance is an unprecedented example of New Zealand seafood sector pre-competitive collaboration. The critical steps to deliver this transformation in thinking and practice to the seafood industry were:

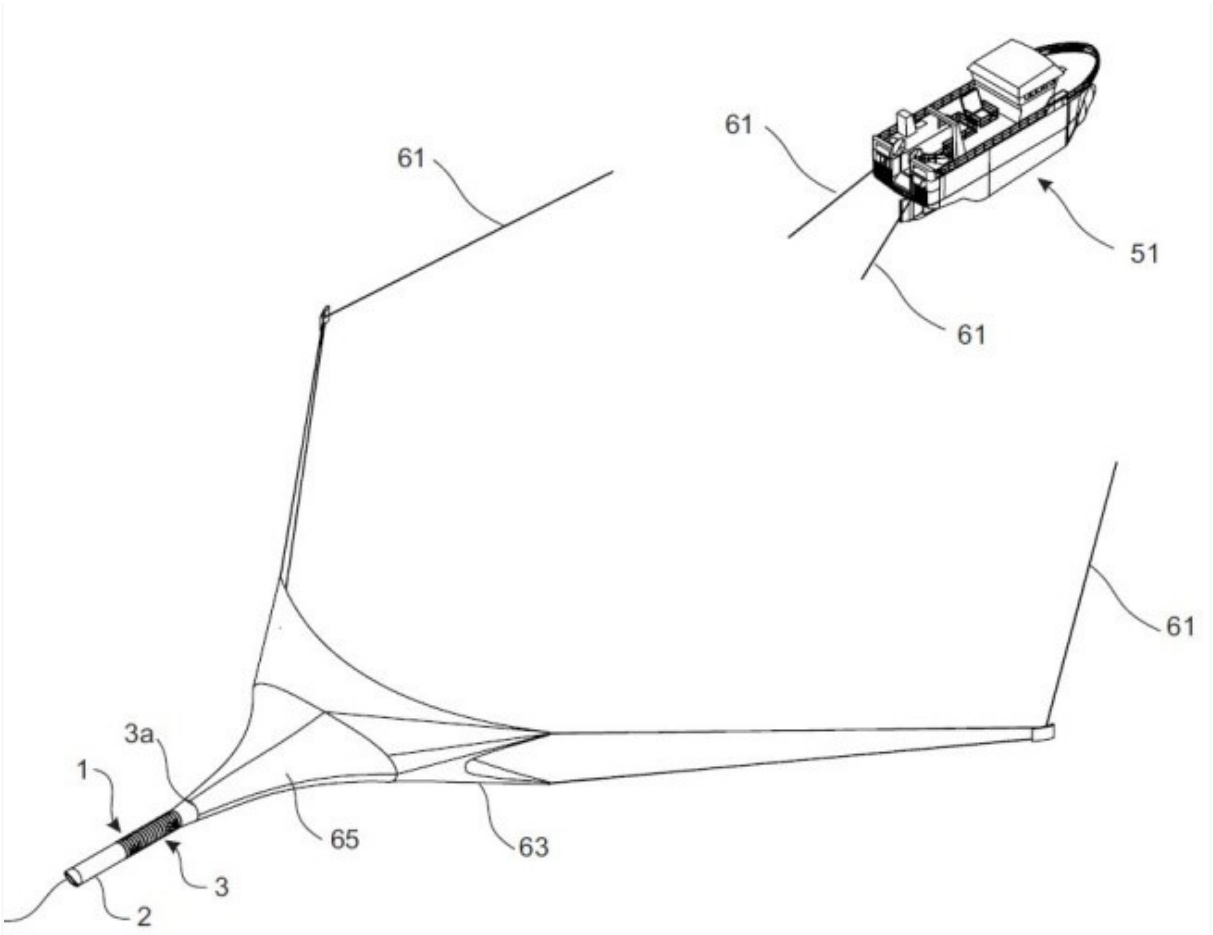
- Advance the design and development of novel wild fish harvesting, handling and processing technologies, to the stage of commercially viable equipment for inshore and deepwater vessels and deliver training programmes to industry to ensure their implementation.
- Work with MPI to demonstrate that the new harvesting technologies meet or exceed their sustainability standards for current harvesting methodologies, to

enable regulatory change so that the new harvesting methodologies can be used commercially.
- Develop methods, protocols and technologies for holding and on-rearing live fish caught using the new methods, to allow fresh fish to be provided when required by the market[6].
- Develop a NZ Inc. branding strategy for seafood products caught and handled using these new rested harvesting technologies and develop exemplar products to demonstrate the high-quality attributes valued by seafood markets.

Key Concept – Transforming Bulk Seafood Harvesting
This initiative sought to completely rethink bulk harvest from traditional trawl incentives i.e.:

- Regulation to limit fishing efficiency e.g. net mesh size aiming for smaller fish escapement – although fish are often damaged escaping and may clog the mesh.
- Discarding unwanted fish species and sizes to reduce handling and storage costs and make room on board for more valuable catch.
- Enforcing anti-discarding rules is difficult.
- Little or no restrictions on where trawling could occur.

Fish-friendly, Controlled, Low Velocity Harvesting Produces Happy Fish
This research programme built on previous research investigating quality attributes, fish tissue physiology and controlled environment trawl cod end development (See Figure 1)[7]. Inherent fish muscle biochemical properties mean that rested fish has a longer shelf life, translucent appearance and firm texture, as opposed to the opaque appearance, fragile and flaccid texture and poor processing and storage properties of exhausted fish[8].



Precision Seafood Harvesting

Figure 1. The Modular Harvest System configuration

Precision Seafood Harvesting

Figure 2. The translucent quality of PSH caught hoki.

A prototype inshore trawl cod end was developed which created conditions matching target species' stamina, senses and behaviour. This comprised a low cost, self-inflating, modular fish 'refuge' attached in the place of the netting cod end bag. This is landed, retaining the harvested fish completely differently, from how a standard cod end is landed onto a fishing vessel deck.

As one industry participant involved commented:

"It was a mind bender when the scientists told us they were proposing that we tow a bag of water through the water."

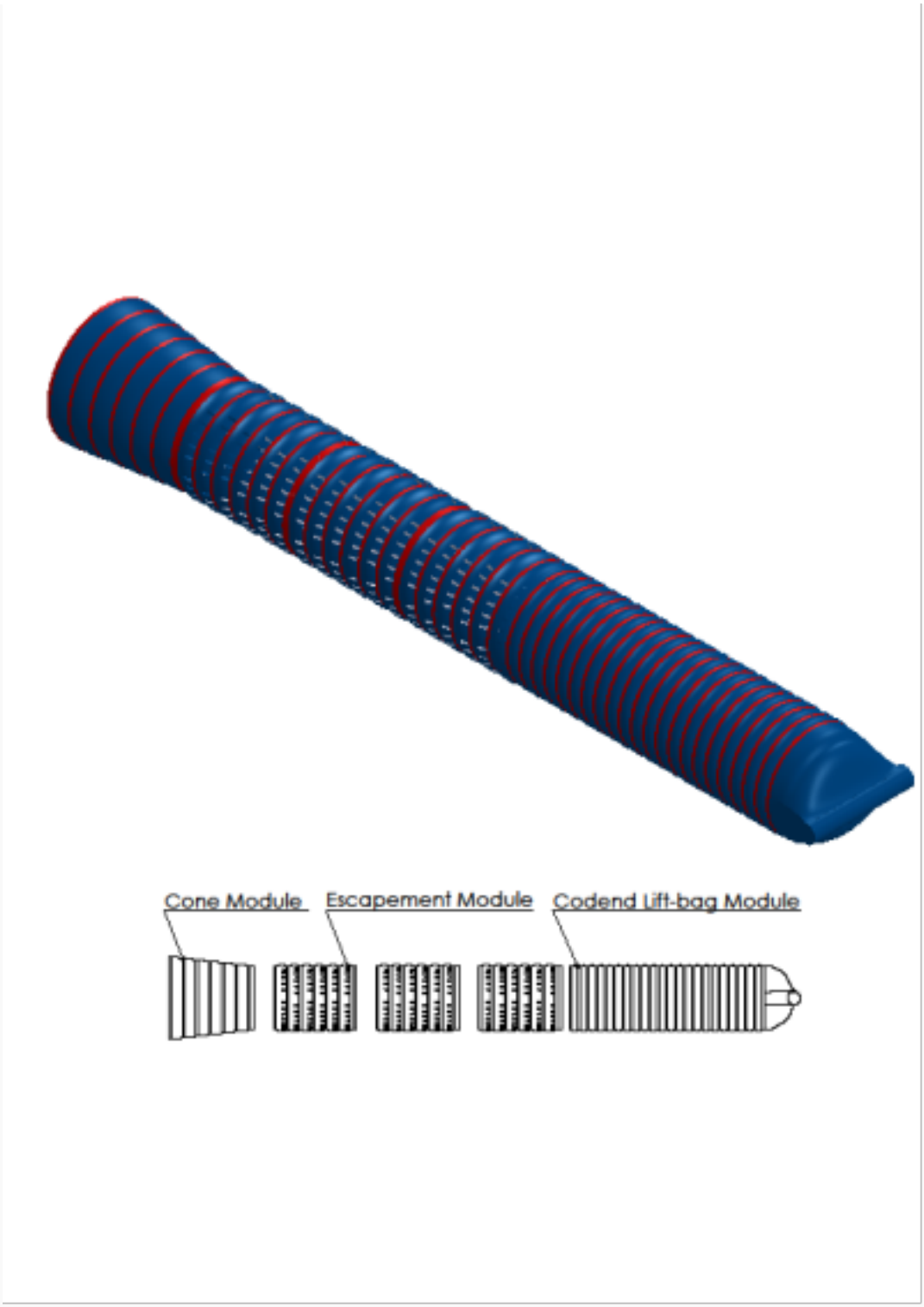
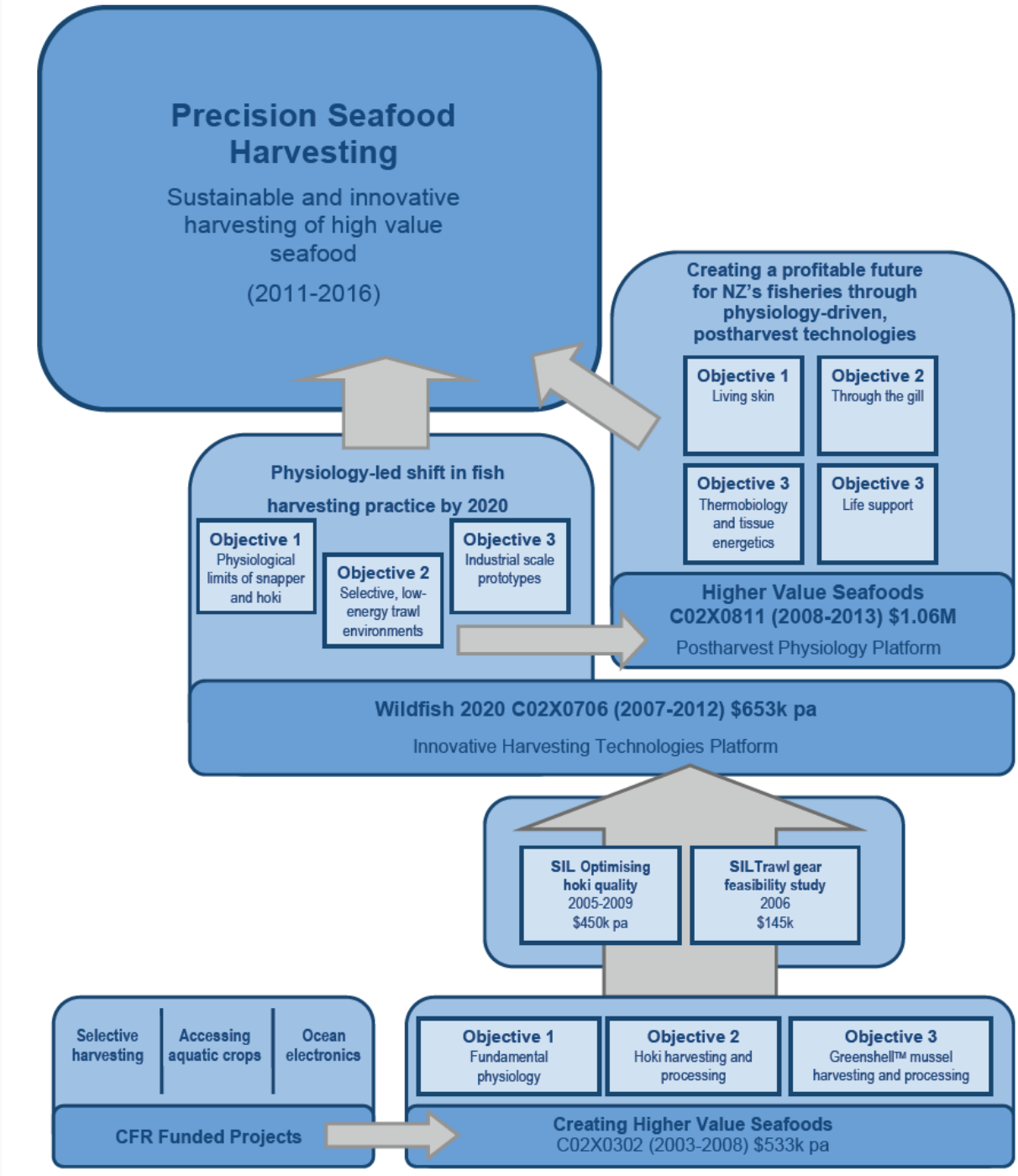


Figure 3. The Modular Harvest System configuration.

The critical mechanism is to control the water velocity within the modular harvesting system to within the stamina of the catch, allowing fish to regain control, individualise and look after themselves during the fishing event. The graded water flow inside the MHS is achieved with strategically positioned and sized escapement ports along the length of the MHS to allow water (and undersize catch) to escape. The PSH PGP programme set out to

explore how to exploit the target species' own physiological control systems to maintain their condition during the capture process through reducing physical and tissue degradation. Prototypes of the proposed new technology have already shown their ability to allow unharmed juveniles and small adult fish to escape at capture depth. Such fish have a very high chance of survival compared with fish that may escape from a conventional trawl near the surface and which are often both exhausted and injured. An objective of the new designs was to target an optimal size range of species for both sustainability and value. Allowing small fish to escape unharmed is key to maintain stock productivity and a significant opportunity to improve commercial fishing stock sustainability overall. Furthermore, the new harvesting structures developed for bottom trawling have the potential to be active hydrodynamic bodies that "fly," rather than be dragged across the sea floor, although this research component remains to be developed.



Precision Seafood Harvesting

Figure 4. Research progression towards rested harvesting

Innovation Snapshots

1. Research

- PFR scientists had extensive experience in improving fish flesh quality, harvest and rearing, and were linked into world leading fishing gear technological improvements.
- The PGP drove collaboration, co-investment and innovation.

- The technology research and development investment risk was made acceptable through the 50/50 industry/government funding model and fishing vessel access.
- Scientists iterated with the skippers, company vessel managers, and government observers.

2. Technological

- Multiple interchangeable components (modules) designed for different cod ends and use in inshore fisheries and some mid-depth and deepwater fisheries.
- PFR scientists designed the MHS, new onboard handling systems, fish quality assessments and underwater in-trawl camera equipment required for the research.
- Significant new vessel innovation and existing fleet reconfiguration to enable MHS uptake and optimise quality improvements.
- The technology has enabled fishing strategy changes including longer tows without compromising fish quality.

3. Regulatory

- Industry could land the fish, caught under experimental conditions (MPI Special Permits) during the research phase, and record it against commercial catch (quota).
- The regulatory changes under the MPI Future of Our Fisheries review included the new Enabling Innovative Trawl Technologies (EITT) regulations, which create an innovation pathway to shift from concept to approved commercial harvesting systems.
- Deepwater permits were approved.
- Industry's need to have the use of the MHS incentivised over mesh e.g. recognising the difference in discard survival for quota declarations or enabling release at depth technology when using the MHS (mitigate against protected species captures etc.).

4. Commercial

- Industry could recoup lost commercial vessel operational time/cost through being able to sell MHS fish.
- Creating many more product development options through improved raw material quality.
- The industry partners have 3-year exclusive gear use rights from programme completion, 31st March 2019.
- PSH and PFR have patented the gear and will sell the Intellectual Property (IP) worldwide.

- The trademarked Tiaki brand and logo (Fig 4.) were created to market PSH seafood products.

5. Improving Sustainability

The environmental performance objectives the PSH PGP set out to achieve were:

- To selectively harvest species sought by the market at any given time:
  - reduce the incidental catch of undesired fish species, and,
  - reduce any potential mortalities from discarding undesirable fish at sea.
- To harvest only desired target species size:
  - to reduce juvenile mortality rates and conserve the stock overall, potentially leading to increased fish populations as the juveniles grow and reproduce, and,
  - to match product characteristics to market demand.
- To harvest seafood species only and no other marine biota of any type.
- To minimise impact on the benthic environment, as an important part of the marine
  environment in which seafood harvesting takes place.

It was envisaged that the proposed seafood harvesting transformation would improve sustainability by reducing impacts in at least the first three objectives. Reducing by-catch and improving selectivity will ensure that fish stocks are maintained and can grow into the future. Reducing benthic damage was an aspirational goal potentially to be addressed during later stages of gear design. In the feasibility studies for the PSH project there were no financial estimates made of the improvements in resource sustainability. It now appears that the environmental impact of small fish escapement and return to the sea live during or post harvesting are likely to be as significant as the commercial benefits calculated from improved value of fish quality.

Workstream Results

TIĀKI
FISHED WITH CARE

Figure 5. The PSH Tiaki Brand and Logo

1. Programme Management

The partnership functioned for 7 years across multiple challenges in research and development, the regulatory environment and commercial roll-out.

2. Communications, Marketing, Brand Development and Intellectual Property
Consistent messaging of programme achievements is essential and was managed with a professional communications strategy.
A *trademark protected brand* "Tiaki" was developed. Tiaki means to save/guard/protect/care for, in Te Reo Māori.
Intellectual Property: the MHS IP is largely patented in countries of interest and owned by PFR with the co-investor companies benefitting from percentage royalties and through having the right of perpetual use.
Technology Uptake and Performance: PSH has worked with Trident Systems[9] to develop an acceptable format of quarterly reporting based on catch effort data for the new designs, in both the inshore and deepwater fisheries. These describe rapid technology and the reporting and analysis will continue.

3. Revolutionary Trawl Technology
MHS comes in two inshore and one deepwater sizes. The deepwater design was approved for commercial use for the Hoki, hake and ling fisheries in May 2018. MPI is considering the inshore design application. The MHS designs all maintain the caught fish in a low water velocity environment which the co-investors believe significantly and positively effects:

- landed fish quality;
- potential discard survival; and,
- reducing damage during escapement.

The designs have some significant and unique requirements for the construction material strength, and their manufacture has been tailored for the PSH programme and is being fine-tuned for commercial usage. The individual modules have unique identifiers fitted to track working life, catch performance, and to secure against IP theft. These PSH designed security systems were co-selected with MPI to meet new compliance system requirements also tailored to PSH. MPI is approving the designs based on their performance against four criteria and where they have proven a "no worse" performance against the existing mesh trawl designs:

- Selectivity (size),
- Species composition,
- Benthic impacts, and;
- Protected species.

There are now anecdotal reports that the MHS designs may also be slightly more fuel efficient than the mesh designs which is a further research area. Furthermore, in the inshore fishery MHS use has enabled fishing further from port and in deeper waters, improving catch composition (species) and reducing overall quantities of undersized snapper being landed (quarter on quarter). The deepwater vessels are now experimenting with the escapement hole sizes in the approved MHS design, to further decrease the capture of smaller sized Hoki. Furthermore, observer evidence is that the MHS has a lower incidence of seabird interactions than mesh trawls.

4. Onboard Handling

Deepwater: To date the industry standard Hoki tow time has been 4 hours. The lively condition of MHS HokiHoki has encouraged tow time experimentation and demonstrated that the fish can be hauled in significantly better condition and when the factory needs new raw material, resulting in:

- increased vessel efficiency,
- better value-add results; and,
- increased deck crew availability to the factory.

The programme has developed optimal Hoki handling protocols and invested in modifying a fish pound on-board the Sealord vessel "Ocean Dawn" to prove full scale application of the protocols for chilled and stabilised fish pound storage.

Inshore: The inshore designs aimed to improve (i) fish quality and (ii) discard survival, with several vessel fish handling system designs improving quality. A relationship between tow catch quantity and fish quality exists and is being explored through developing a prototype "Datalink" system to improve skipper tow performance control. PSH has demonstrated MHS discard survival potential which is exciting the fishermen using the gear. This remains to be independently verified.

5. Wild capture, on-rearing

This was not progressed, and its objectives were either dropped or merged with other projects.

6. Validation

Proving the new technology performance through developing new performance metrics for sustainability (selectivity and survivability), fish quality, and measurement and reporting methods is a critical ongoing challenge. For example, determining the acceptable evidence levels that are required to prove the "no worse" case against the four criteria and secure regulatory approval. It is difficult to state definitively which methods or metrics are universally accepted by the PSH stakeholders, and decisions are based on a balance of all operational results, which vary by company, and are not always an obviously "better" or "worse" position. This is particularly true when considering differences in species composition between two different harvest systems.

Conclusions

This research has demonstrated how innovation, collaboration, perseverance and culture change can break the mould of an entrenched commercial fishing harvest method. MHS reduces defects and increases product quality, landed values, product cascade outcomes and yields, in key inshore and deepwater species. There remains the potential to further develop novel, value-added seafood products/categories for new, higher value markets. It has also improved fuel and operational efficiency, enabled changes in fisher behaviour, and boosted morale. All three companies are committed to fleet modernisation, which MHS success will support, and which has implications for quota holdings and family fishing businesses. Once an individual and/or entity (company or institution) are on a sustainability journey and achieves some successes, the improved sense of capability and multi-faceted rewards create potential to reinforce their sustainability journey and become even more ambitious. This is the case with the PSH commercial partners. In such a significant multi-year, multi-stakeholder, and multi-strand research project, iteration and adaptation are inevitable and can challenge evolving management agencies.

A significant unintended benefit is the strategic fishery sustainability potential the PSH MHS gear brings given its greatly improved larger fish selectivity (at least Hoki and snapper), i.e. increased juveniles escaping alive, undamaged, and theoretically able to grow on and reproduce. This remains to be formally quantified and yet has significant ramifications for overall population health as well as for the science modelling and thus for management. At least industry participants believe that this gives greater certainty that the major fish species' populations that they rely upon can be fished with increased precision and thus caution. They accept that this caution is essential given the major risks to commercial fisheries from, for example, climate change and other accumulating marine environmental threats such as sedimentation. This greater overall confidence enables investment, deeper analysis, and reflection on how to tackle the harder public policy and science issues to ensure sustainable seafood production, such as securing the biogenic habitats that underpin seafood production across the EEZ.

Key remaining challenges are to: (i) ensure further innovative research capitalises on the knowledge and momentum to date; (ii) agree upon appropriate metrics across industry and government to measure performance; iii) fine tune the implementation of new regulation; (iv) transition to a modern New Zealand fishing fleet using the MHS; (v) research the performance of the MHS in "flying over benthic habitats"; and (vi)

support the transformation of bulk harvest globally to underpin truly sustainable fisheries and marine ecosystem health recovery.

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