SPATnz End of Programme Review

Primary Growth Partnership, SPATnz Programme Evaluation Report

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Submitted: August 2020
Version: 2.0

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Executive Summary

The objective of this independent report is to provide an independent evaluation of the Primary Growth Partnership (PGP), now known as the Sustainable Food and Fibre Futures Programme, SPATnz Programme. The Programme is a partnership between Shellfish Production and Technology New Zealand Limited (SPATnz) and the Ministry for Primary Industries (MPI). This evaluation analyses the:

- Achievements and expected outcomes.
- Performance against its key performance indicators and the delivery of the targeted economic benefits to the Partners, mussel industry, and New Zealand economy.
- Programme management and governance.

The lessons learned from the Programme that would benefit the Programme partners, other programmes and/or the SFF Futures Programme investments in the future.

SPATnz Ltd, a subsidiary of Sanford Limited, co-invested $22.6 million with MPI in the PGP Programme. The purpose of the Programme was to revolutionise New Zealand's Greenshell™ mussel (GSM) industry by domesticating GSM and developing selectively bred, higher-value products. The programme commenced in November 2012 and was conducted over a seven-year period. The estimated economic benefit was $98.6 million per annum compared with wild mussels based on 2019 performance data and 30,000 tonnes per annum of hatchery production. It expected to create between 480 and 1,100 jobs and generate $204 to $485 million per year of sales to New Zealand's economy by 2026 (based on hatchery(s) supplying 30,000 tonnes and 90,000 Tonnes per annum). The economic benefits to New Zealand are estimated to be $81 to 193 million by 2026 (increased GDP per year).

The total budget was $26.1 million (actual commitments were $11.3 million invested by MPI and $11.3 million industry investment). All main work-streams were completed, and all core goals were achieved with a total spend of $22.6 million (the programme was $3.5 million underspent against the original budget).

Overall, the Programme has led to a transformational change. It has brought New Zealand forward as a world leader in mussel hatchery technology and processes, with potential for further step change for the industry. The Programme's major achievements and benefits include:

- Selectively bred spat of GSM with enhanced production and market characteristics:
    - Certainty of supply over wild caught spat
    - Faster growth of selectively bred mussels
    - Uniformity of mussel size and quality
    - Ability to selectively breed favourable traits
    - Increased retention of mussels
    - Better opportunities for value-add products

- Developed knowledge and capability to produce hatchery-reared GSM at a commercial scale
- Hatchery and sea-based nursery infrastructure.

Findings

Significant progress has been made in achieving all objectives and outcomes, and the Programme is already accruing significant benefits to Sanford and the entities it supplies through SPATnz. This in turn adds value to the broader mussel farming and aquaculture sector by providing clarity of the opportunities offered through reliable high quality spat.

In addition, selectively bred mussels can be developed with qualities specifically for high value markets which assists with evolution of the mussel sector to a higher value product offering.

The Programme has major additional potential, through expansion of the existing hatchery and building additional hatcheries to meet market demand. The North Island is not currently supplied by SPATnz despite a critical spat supply shortage, as hatchery capacity needs to be increased to meet demand.

There were significant risks and issues that were managed effectively by the Programme and its Partners. A number of areas will be progressed beyond the current Programme life, to maximise the potential of SPATnz and meet the obligations under PGP, including:

- Expansion of the SPATnz hatchery
- Building a new hatchery in a different location as a measure to increase supply and de-risk against biosecurity and natural hazards
- Further selective breeding for traits to meet market demands
- Further R&D and process improvement to continually improve spat production efficiency
- Providing investment and licensing opportunities to the industry.

Programme Progress

The Programme outcomes, objectives and expected benefits were ambitious, specific, clear and measurable providing the Programme Management with clear accountabilities. The projected benefits of the SPATnz Programme already exceed those predicted for 2026. This is due to the growth advantage of hatchery spat and the additional crop yield at harvest that was not anticipated. Selective breeding was anticipated to drive a 35% increase in production by 2026. However, a Marlborough grower's productivity can already be doubled with hatchery strains available today. Other benefits achieved include the ability to selectively breed favourable traits such as growth rates, shell strength and colour, and meat content. Moreover, the Programme

has reduced the environmental footprint and increased resilience against biosecurity and climate change risks.

Governance, Collaboration and Programme Management

Governance was highly effective, with reporting and decision making well managed, and the relationship with the Programme Manager was very strong. The Programme Steering Group (PSG) had a strong balance of skills (both technical and strategic) and level of representation in terms of management and decision making. The Programme was managed to an exceptionally high standard, achieved its goals and objectives, and was supported by strong leadership with an outstanding, high calibre research team.

Overall, the lessons learned include:

- the importance of industry's role as a key investor embedded within the research
- the importance of people, the right skills, and culture within the Programme and PSG
- having a clear line of sight over issues and risks
- the significance of being flexible and adaptive around timeframes, budgets, and projects
- having partners that are clearly aligned and committed to a shared vision, mission and strategy.

Recommendations

The benefits and potential benefits described, confirm that there will be increased demand for hatchery bred spat over wild spat. All interviewees confirmed this. The challenges associated with spat supply are especially acute in the North Island which currently does not receive any product from SPATnz.

Recommendation 1. *Sustainable Food and Fibre Futures (SFF Futures) programmes could use SPATnz as an exemplar to balance science research and commercialisation using an adaptive and systematic approach to problem solving. This may include having different types of agreements including Intellectual Property arrangements for different programmes (e.g. different exclusive periods).*

Recommendation 2. *Future SFF Futures programmes to use SPATnz as an exemplar for programme management, governance, reporting, and risk management.*

Recommendation 3: *Future SFF Futures programmes should ensure consistency across how the PSG and Programme are resourced. This has provided benefits including collaboration, goodwill, trust, and retention of highly unique skills.*

Recommendation 4: *Future SFF Futures programmes should ensure a blend of technical and strategic skills on the PSG.*

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Recommendation 5: *Future SFF Futures programmes should ensure that there are the tools, capability, and project management frameworks to be flexible and adapt for efficient problem solving which is characteristic of taking on innovative ventures.*

1.0 Introduction

1.1 The Primary Growth Partnership

MPI's strategy is *"New Zealand will be the world's most sustainable provider of high-value food and primary products"*. To help achieve this, MPI is co-investing with primary sector industries to innovate through the PGP. The PGP aims to drive substantial gains in economic growth and sustainability through shared investment in complementary and mutually supporting projects that work across the primary industry value chains. A key requirement of PGP Programmes is that they must deliver benefits to New Zealand through investments that are innovative and additional to existing initiatives and work programmes. Without PGP investment, these initiatives would be either unlikely to proceed or proceed on a much-reduced scale or pace.

The PGP was replaced by the Sustainable Food and Fibre Futures Programme in 2018 (SFF Futures) and has the strategic objective of delivering long-term environmental, social, economic, and cultural outcomes for New Zealand through innovation.

1.2 Overview of the Shellfish Production & Technology (SPATnz) Programme

The Programme is a collaboration between the Crown and SPATnz. SPATnz is owned by Sanford which alone represented ~35% of New Zealand's GSM industry and processes mussels for a total of ~50 companies. The purpose of the Programme was to revolutionise New Zealand's Greenshell™ mussel industry by domesticating GSM and developing selectively bred, higher-value products. The programme commenced in November 2012 and was carried out over a seven-year period with an estimated economic benefit of $98.6 million compared to wild mussels in 2019. It expected to create between 480 and 1,100 jobs and generate $204 to $485 million per year of sales to New Zealand's economy by 2026 (based on hatchery(s) supplying 30,000 tonnes and 90,000 T). The economic benefits to New Zealand are estimated to be $81 to 193 million by 2026 (increased GDP per year).

The total investment budget was $26.1 million ($11.3 million invested by MPI and $11.3 million industry investment). All main work-streams were completed, and all core goals were achieved with a total spend of $22.6 million (of the Programme was $3.5 million underspent against the budget). An economic benefit over the lifetime of the programme was achieved with an estimated economic gain of $98.6 million per annum forecast for 30,000 tonnes per annum production based on data and mussel breeds available in 2019.

Overall, the Programme has led to a transformational change for the industry. It has brought New Zealand forward as a world leader in mussel aquaculture, with potential for further step-change for the industry. The key success is enhanced performance,

consistency and quality of selectively bred mussels. The major achievements and benefits include:

- Selectively bred spat of GSM with enhanced production and market characteristics:
  - Certainty of supply over wild caught spat
  - Faster growth of selectively bred mussels
  - Uniformity of mussel size and quality
  - Ability to selectively breed favourable traits
  - Increased retention of mussels
  - Better opportunities for value-add products.
- Developed knowledge and capability to produce hatchery-reared GSM at a commercial scale
- Developed hatchery and sea-based nursery infrastructure.

1.3 Independent Review

An independent evaluation of the SPATnz Programme is required under the PGP Agreement. MPI's Investment team commissioned Maven Consulting to undertake the evaluation. A midterm review was undertaken by Sapere and presented to the Programme Partners and made publicly available in July 2016.

1.4 Scope

The objective of the evaluation is to provide an independent assessment of the:

- Achievements and expected outcomes from the Programme.
- Programme's performance against its key performance indicators and the delivery of the targeted economic benefits to the Partners, mussel industry, and New Zealand economy was also assessed.
- Programme's management and governance.
- The lessons learned from the Programme that would benefit the Programme partners, other programmes and/or the SFF Futures Programme investments in the future.

The Terms of Reference describe the scope of this evaluation as including (Appendix 1 contains the full Terms of Reference):

- Outcomes and benefits accomplished and benefits to New Zealand.
- Execution of management, governance and reporting.
- Programme resources.
- Assumptions of economic benefits.
- Programmes risks and barriers.
- Internal and external reviews recommendations.
- Lessons learned.

- Other internal and external factors affecting the likelihood of success of the programme.

The scope of the evaluation does not include the rationale for investing in the Programme. We have not attempted to provide an assessment of whether the programme will deliver the intended outcomes and economic benefits not yet achieved. There is no way to reliably assess likelihood of achieving the intended post-SPATnz Programme activities. In addition, it is difficult to speculate on the impact of COVID-19 on achieving projected benefits and outcomes.

1.5 Approach

The review was conducted in May and June 2020. The review has been based on:

1. Desktop review of SPATnz's Final Report, annual plans and quarterly reports, Outcome Logic Model, outcome and benefit measures/KPIs with performance data collected, original Business Case, Independent Progress Review Report, risk registers, and research reports.
2. Semi-structured interviews conducted with 17 stakeholder representatives including: Programme Steering Group, Partner senior leadership team, industry representatives including growers, Cawthron Institute staff, MPI, and a member of the Investment Advisory Panel (see Appendix Two for a full list of interviewees).

All interviewees were provided with a range of topics for discussion ahead of the interview but not a structured set of questions. This allowed the interviews to be focused without restricting the interview to only those specific questions provided ahead of time. The specific focus of each interview was tailored depending on the perspective of the interviewee. Interview notes were taken and qualitatively analysed, with a focus on identifying trends and consistent themes arising from the interviews. No attempt was made to undertake quantitative analysis from the interviews. This approach is consistent with other PGP Reviews undertaken by Maven Consulting.

Through these interviews, the reviewers sought to understand the underlying issues impacting the programme, factors impacting performance, key lessons learned, and opportunities for improvement within the PGP (now SFF Futures) Programmes. The evaluation has avoided an explicit breakdown of views by individuals interviewed. The qualitative analysis of both individual interviews and the full range of interviewees allowed clear and consistent themes to develop, which comprise much of the findings provided in this review.

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2.0 Summary of Overall Findings

2.1 Outcomes and Objectives of the Programme

The Programme is made up of 12 short, medium and long-term intended outcomes and seven intended benefits for co-investors, the mussel industry, and wider New Zealand. The Programme was divided into six projects incorporating 11 objectives to achieve the outcomes. Table 3 provides a summary of these, which are derived from the original Business Case.

2.2 Business Case Outcomes and the Outcome Logic Model

The projected outcomes of the Programme included increased returns from shellfish aquaculture, delivered in a way that reduces impacts on the environment and develops capability for future economic growth. The outcomes are presented in the Outcome Logic Model (OLM) which was updated in August 2016 to account for the growing demand for spat (Figure 1). The outcomes are organised into three stages and are reported against their progress in

Table 2:

- Short term outcomes (2018 – 2020) – six outcomes
- Medium term outcomes (2020 – 2024) – five outcomes
- Long term outcomes (2025 -) – one outcome

2.3 Anticipated Benefits

The Business Case presented four areas of benefits for the industry and the wider New Zealand economy. The OLM also included three additional benefits for the industry and New Zealand (Table 1). Progress against achieving these benefits is discussed further in Sections 0 and 4.0.

Table 1. Business Case and Outcome Logic Benefits

Business Case Benefits	Outcome Logic Additional Benefits
Economic – both to industry and the wider New Zealand economy	SPATNZ contributes to New Zealand Greenshell™ Mussel profile and provenance in key markets
Environmental sustainability – reducing the environmental footprint	New employment opportunities in New Zealand aquaculture including for aquaculture student graduates
Benefits to Maori – expansion of Maori assets, increased income to Maori, development of skills in aquaculture and employment opportunities in a growing industry	
Capability development – infrastructure and expertise	Collaboration of co-investors and share growers across the New Zealand Greenshell Mussel value chain

2.4 Overall Findings of Each Project and Associated Objective

This Section evaluates progress against the outcomes in the OLM (

Table 2). All but one of the intended outcomes are marked as "Achieved". The outcome "*Reduced exposure of New Zealand GSM to sea-based biosecurity risks*" was given a blue progress rating, noted in the Annual Plan 2018-2019 as *"unrealistic"* as it assumed that the increasing availability of hatchery spat would reduce the amount of Kaitaia spat required. Kaitaia spat is attached to seaweed and harvested along with other organisms that may also be attached. Given the increase in new consented water space for mussel farming across New Zealand, demand for Kaitaia spat will continue to be strong. However, hatchery spat does reduce biosecurity risk by providing an alternative source of spat if wild spat was affected by a biosecurity event.

Progress against each outcome and corresponding objectives is provided in

Table 2 and Table 3. Outcomes from the OLM are linked to associated Projects and objectives and evaluation of progress is discussed in more detail within Sections 0 and 4.0.

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Table 2 provides a snapshot of progress to date against the original Business Case outcomes. The Reviewers comments on progress are provided in Table 3.

A progress legend for the following tables is:

	Achieved / On Track		Partially achieved
	Not achieved		Project "parked". Related objectives and outcomes were not applicable.

Table 2. Intended Outcomes from the SPAT Programme (OLM)

ST1	More efficient farming and processing of New Zealand Greenshell Mussels	
ST2	Improved quality and consistency of New Zealand Greenshell Mussel spat supply	
ST3	Reduced exposure of New Zealand Greenshell Mussel to sea-based biosecurity risks	
ST4	Evidence of economic and environmental viability of domesticated Greenshell mussel production	
ST5	New and high value market opportunities for New Zealand Greenshell Mussels	
ST6	New expertise and capability in shellfish breeding in New Zealand	
MT1	NZ Greenshell Mussel industry sales to higher-value markets increased	
MT2	Increased value from New Zealand Greenshell Mussel exports	
MT3	Uptake of new spat capability and technology across the wider aquaculture industry	
MT4	Increased productivity in New Zealand Greenshell Mussel industry	
MT5	Enable Greenshell mussel industry growth by increasing spat supply	
LT1	Sustainable economic growth across the aquaculture industry that contributes to New Zealand Aquaculture Strategy goal of NZ$1 billion in annual sales by 2025	

Table 3. Progress Against Business Case Objectives and Milestones

Project	Objective	Achievement Measure(s)	Progress	Reviewer Comments
Project 1 Advanced Broodstock/Seed for GSM **Budget $19.7 million** **Actual $19.1 million** Achievement measures: • Successful hatchery facility, capable of producing selectively bred GSM spat sufficient to produce 30,000 GWT of GSM per annum by 31 July 2019. • Efficient land-based nursery facility, systems and protocols rear GSM from settlement to 1 mm with <30% mortality at 30,000 T/y scale. • Identification and development of broodstock that will increase production efficiency and product value.	1.1 Develop Operational Spat Hatchery and Land-based Nursery	A world first land-based hatchery and land-based nursery capable of producing sufficient spat for 30,000 T/y GWT of GSM		The Programme has successfully demonstrated that hatchery production is both technically feasible and economically viable. A world-class hatchery facility was designed, capable of producing selectively bred GSM spat sufficient to produce 30,000 GWT of GSM per annum. The infrastructure was built to withstand a greater than one in 250-year flood events due to the site being flood prone. This success was due to strong leadership, effective programme management with an outstanding team coupled with the ability to be flexible and adapt the Programme as and when needed, overcoming all challenges. A major breakthrough was overcoming the challenges associated with larval rearing.
	1.2 Identify and advance broodstock lines through selective breeding	• Targeted selective breeding gains (see milestones) through the production pipeline are achieved by 31 July 2019 • At the conclusion of the Programme, a library of genetically improved GSM strains and associated data is managed by BreedCo for use by industry • Factors controlling seasonal condition of		The Programme has successfully developed a library of genetically improved GSM strains and associated data (managed by BreedCo). The breeding gains were achieved faster generationally than expected. For example, selectively bred hatchery strains reached harvest size at least 20% faster than wild control mussels. This target was exceeded by a factor of more than two-fold on average across ten Marlborough farms. Moreover, the Programme was able to build knowledge around factors controlling the seasonal condition of mussels, the influence of source population, birthdate, and season and the impact of traditionally poor growing sites on breeding gains. These are now better understood as a result of the research undertaken. The selective breeding programme holds

		mussels are understood by 31 Jul 2017 • Impact of traditionally poor growing sites on breeding gains is understood by 31 Jul 2019		many opportunities for the future through the identification and selection of commercially valuable traits of GSM. In a 2018 review, the breeding programme was said to be highly cost effective and "*compared very favourably to other shellfish and aquaculture breeding programs on a global scale*" (Kube, 2018).
	1.3 Train workforce capable of implementing GSM hatchery spat supply.	Mussel hatchery teaching material delivered to tertiary aquaculture course by 30 Nov 2015.		In 2010, there were 4-5 people specialising in GSM hatchery technology. The Business Case anticipated a team of 15 people. Currently, SPATnz has 25 staff. Most SPATnz staff have science or aquaculture qualifications and are trained on-the-job to be specialists in the area they are assigned to. The Reviewers note there was a highly successful relationship with Nelson-Marlborough Institute of Technology and that training was achieved with minimal expenditure. SPATnz has fostered a highly effective recruitment pathway, created jobs, and increased retention of skills within New Zealand.
Project 2 Sea Based Nursery Production Systems **Budget: $1.0 million** **Actual: $961,522**	2.1 Develop a high throughput sea-based nursery production system	• Sea-based nursery system capable of producing spat for 30,000 T/y harvest of GSM • Spat yield - retention of hatchery spat at 15mm		Inconsistent retention and survival of spat at sea were among the most complex and challenging problems addressed under the Programme. Retention is the key to profitability. While hatchery spat typically gave much higher retention (average retention with the new method exceeds the target of 37%), results during the early phases of the Programme were variable and this prompted research to improve consistency and overall spat yield. Project 2

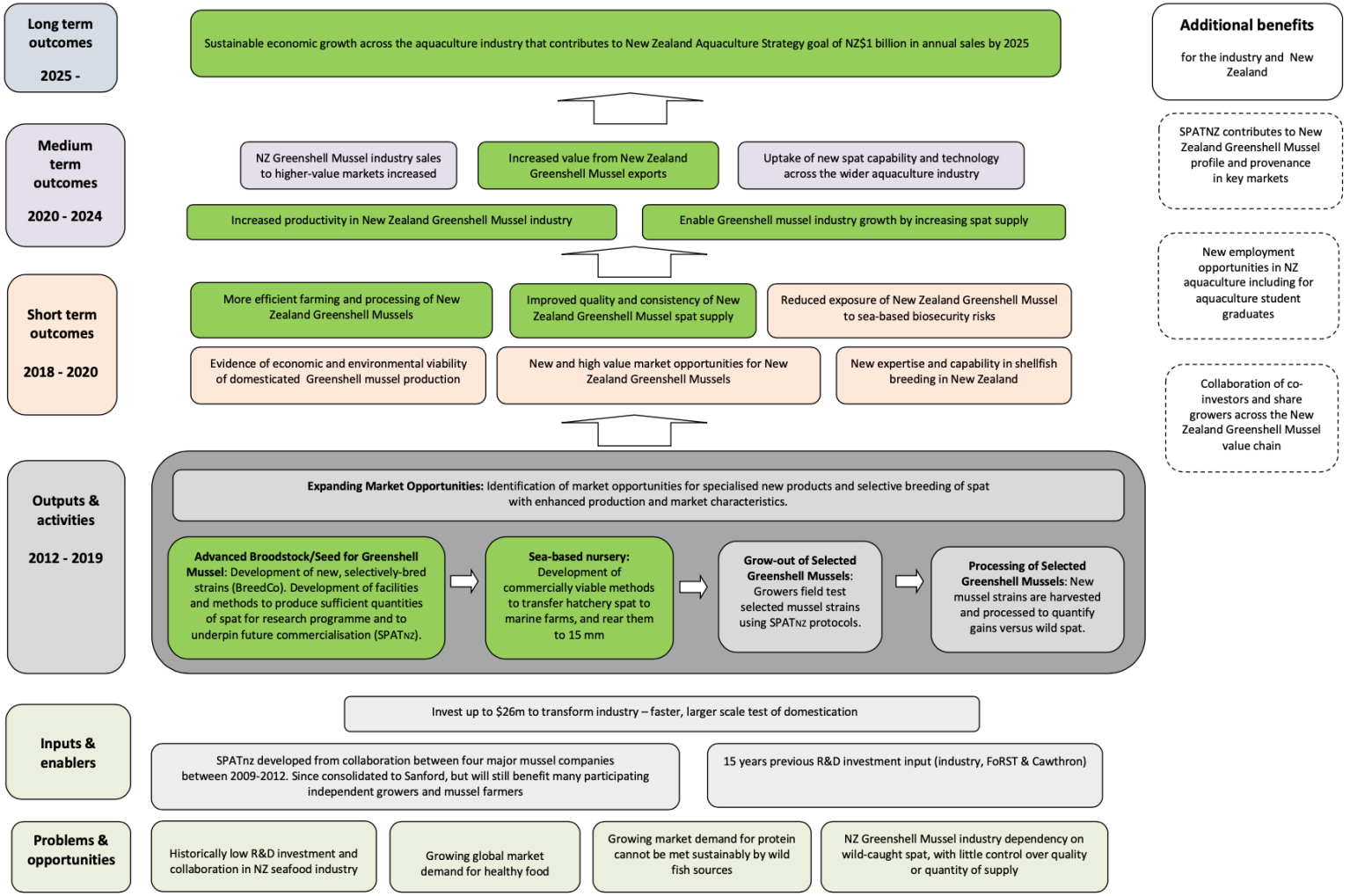
Achievement measure: • Development of a sea-based nursery production system that retains at least 30% of the spat deployed by the hatchery		increased to >30%. Technology to inter-seed 10-15mm spat and cope with, or remove, competing biofouling		faced a myriad of environmental challenges including seasonal variation, climate patterns, nutrient supply, predation (e.g., by fish), biofouling (e.g., sea squirts, sponges, weed). With focussed research, effective risk management, and a capable team, the Programme successfully applied techniques and equipment to exceed the target of 37% retention in the last year of the Programme as well as developing techniques and equipment to efficiently inter-seed GSM at 10-15 mm with <10% losses by 30 Apr 2017. This ensured the sea-based nursery system was capable of producing spat for 30,000t/year harvest of GSM. Milestone 2.1.2 was partly achieved but determined by the Reviewers to be on track (*Assess the prevalence and impact of biofouling issues in sea-based nursery sites and develop prototype biofouling treatments to remove or minimise problematic fouling species)*. Fouling had a major influence on spat losses at times, but spatial and temporal variation in the occurrence and severity of marine fouling made it difficult to generalise about patterns. Various means of treating fouling organisms were tested and one of these is scalable if required.
Project 3 Growout of selected GSM **Budget: $1.9 million** **Actual: $440,380** Achievement measure: • Selectively bred GSM hatchery spat are grown to harvest size and	3.1 Field test selectively bred GSM strains	Report quantifying the gains achieved by selective breeding and hatchery spat production		This was a major (positive) and partly unexpected outcome with faster growth rates, higher crop retention, less fouling, and therefore higher net crop yield per metre (55% higher for hatchery mussels than for Kaitaia spat and 25% higher than Golden Bay spat). The growth advantage of hatchery mussels was evident at all ten sites. Growth benefits provide growers the opportunity to maximise on productivity (for example, seeding mussel ropes at a higher density in better growing sites; it also made historically slower growing sites more productive). These benefits allow growers to be more flexible in their business operations, utilise

performance traits quantified.				space more efficiently, improving return on investment, and move products through faster.
Project 4 Processing of selected GSM **Budget: $1.1 million** **Actual: With Project 3** Achievement measure: • Robust data on shell breakage and yield following commercial harvesting, transport and processing of selected strains and appropriate controls.	4.1 Factory test selectively bred GSM strains	Selectively bred product increases value of harvest by at least 5% relative to wild-caught spat		No definitive data exists on shell breakage and yield because of algal blooms preventing harvest in parts of the last two years as well as data being "*too noisy*" to establish a difference in hatchery mussels vs wild. The July-October (Q4) 2019 Quarterly Report notes that other factors drive variation in broken shells. There was however successful collection of harvest and factory data for 33 of the 60 strains that weren't impacted by algal blooms. The benefit for reduction of small grade (lower value, higher cost) and extra smalls discarded was estimated to deliver $0.7 M in 2019 to 2026 although estimated to be $8.9 M in the Business Case). There is a limited benefit at present because the pricing for the small grade is strong, and preliminary data suggest that the percentage of extra small discards is low. In addition, less small grade does reduce processing costs.
Project 5 Expanding Market Opportunities **Budget: $904,881** **Actual: $383,878** Achievement measures: • Potential for market growth based on functional foods is	5.1 Undertake market research on functional and sensory properties of GSM	Best market prospect for a functional GSM product identified. Confirmation that mussel strain selections do not compromise sensory qualities		From the beginning, SPATnz Business Case had the PGP Investment Advisory Panel interested in the hatchery potential - the ability to selectively breed for attributes, let alone whether it could be achieved at scale. Planned market research was discontinued when Sanford initiated its own research and commercialisation outside of the Programme. The objective was to develop the best market prospect for a functional GSM product. Research for functional GSM products focussed on the reported anti-inflammatory activity of GSM products.

assessed and best prospects are identified • Market feedback confirms that selected strains maintain sensory attributes desired by the market • Genetic markers aid selective breeding of desirable traits				The sensory panel assessment of selected 2012 GSM families was carried out in a collaboration with Plant and Food Research and the Cawthron Institute. Twenty selectively bred GSM families and three groups of wild mussels were compared using instrumental methods. Four families and two wild mussel controls were compared using a panel of 114 consumers which produced similar overall liking scores with limited differences among groups. GSM families will be well accepted by consumers.
	5.2 Genetic markers for GSM traits developed	• Genetic markers established for at least 2 desirable GSM traits. • Cost-effective genotyping method is established.		SPATnz's research on this topic was progressed in collaboration with AgResearch and Cawthron who have an ongoing research interest in this area. SPATnz provided samples and support for the development of genomic tools. BreedCo Ltd then funded AgResearch to apply those tools to selective breeding research. A Genotyping- By-Sequencing (GBS) method has been established by AgResearch to provide cost effective, high throughput genotyping. Genomic selection has great potential for improving selective breeding in GSM.
Project 6 Programme Management Budget: $1.4 million Actual: $1.7 million Achievement measures: • Efficient management of the whole Programme and delivery of milestones on time and within budget.	6.1 Manage programme delivery	• Project objectives and milestones delivered on time and within budget. • PSG satisfied with Programme Management and Reporting.		The Programme Management is an exemplar for other PGP (now SFF Futures) programmes. The Programme was run effectively with all necessary planning and procedures in place. Communication with all stakeholders was effective and clear on issues, risks, budgets, and timeframes (a dashboard approach was used to communicate these and progress which worked really well for the PSG). This was based on systems for monitoring and management of Programme delivery including annual work plans, annual budgets, financial management systems, and subcontracting systems. There was a strong focus on outcomes and objectives against deadlines. The Programme spent 87% of the $26 million budget. The Spat production protocols project was 5% overspent (17 m spent

				16.2 m budgeted) but this was attributed to biological challenges resulting in the Project taking longer than expected.
	Objective 6.2 Manage and Protect Intellectual Property	• IP is appropriately managed and communicated to the Programme Steering Group and co-investors. • Patents for hatchery/nursery protocols if appropriate by 31 Jul 2019. • Patents secured for new equipment or machinery if appropriate by 31 Jul 2019. • License Agreements Established for utilisation of the improved mussels or IP as appropriate by 31 Jul 2019.		Intellectual Property was managed and communicated effectively using the quarterly reporting process to identify new items of sensitive IP and record them in a register of confidential information. Trade secret was favoured over patenting to avoid issues around retaining IP within New Zealand where it would be impractical to detect and enforce breaches overseas. Expert advice has been provided for utilising the Programme IP. Key commercial and legal terms for future licencing or commercialisation of hatchery technology have been agreed upon.

Figure 1. Outcome Logic Model for PGP Shellfish Production and Technology New Zealand Programme 2012-2019



Note: Green boxes highlight key elements.

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3.0 Findings: Programme Achievements and Benefits

The SPATnz Programme ran for seven years with $22.6 million invested. An economic benefit was achieved over the lifetime of the programme and an estimated economic gain of $98.6 million is forecast for 30,000 tonnes per annum production, based on data and mussel breeds available in 2019. The Programme has brought about a transformational change bringing New Zealand forward as a world leader in mussel hatchery technology and processes, with potential for further step change for the industry. The Programme was variously described by interviewees as one of the *"most successful"* and *"one of those success stories"* of the PGP programmes. It has successfully demonstrated the benefits to growers for hatchery spat over wild caught alternatives.

The projected benefits of the SPATnz Programme already exceed those predicted for 2026 (Table 5) owing to the growth advantage of hatchery spat and the additional crop yield at harvest that was not anticipated. Selective breeding was anticipated to drive a 35% increase in production by 2026, however, Marlborough farm productivity can be doubled with hatchery strains available today (Table 5).

The value of the SPATnz Programme has been recognised in multiple awards, such as the New Zealand Marine Farming Association 2016 Research and Development Award (winner). The breeding programme was also identified as an example of a well-designed shellfish breeding programme in the BreedCo Greenshell™ Mussel Breeding Programme Review (2018).

Figure 2. Six families of mussels grown together, showing family differences in size and shell colouring. (Source: SPATnz Final Report)

Relying on wild spat with the highly variable growth and availability with uncertain supply and vitality has flow on impacts for national mussel production. Overall, as the programme progressed SPATnz was able to selectively grow spat "*bigger and better*" (PSG member), grow spat faster and double production on Marlborough farms while reducing biosecurity and climate change risks. The selectively bred spat was described to have so many advantages to growers including halving the grow-out time which, in a capital-intensive investment, significantly increases the economic returns and therefore profitability for growers. For the wider industry and New Zealand, these are potential benefits.

The major successes are enhanced performance, consistency, and quality of selectively bred mussels. Major benefits include:

- The certainty of supply over wild caught spat
- Faster growth of selectively bred mussels
- Uniformity of mussel size and quality
- Ability to selectively breed favourable traits
- Increased retention of mussels
- The certainty of supply to market
- Better opportunities for value-add products.

When we asked interviewees the counterfactual argument (i.e. if no SPATnz investment had occurred), all interviewees reflected positively over the Programme and its many benefits. Interviewees particularly noted that without the PGP investment, a project like this would not have proceeded because of the risk involved.

Sanford is commended for taking the risk and the achievements that SPATnz has produced as well as safeguarding the industry into a "*better safe place*". For that, SPATnz should be regarded as an exemplar for understanding and managing risk in PGP programmes. A significant risk was the risk of the unknown (due to the duration of the Programme) and the need from industry to share that risk to boost innovation in New Zealand. Equally, interviewees noted that MPI should be applauded because, without its investment in science, there will not be any investment.

Overall, the lessons learned included the

- importance of industry's role as a key investor embedded within the research
- importance of people, the right skills, and culture within the Programme and PSG
- having a clear line of sight over issues and risks
- significance of being flexible and adaptive around timeframes, budgets, and projects.

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3.1 Economic Benefits

The Programme outcomes, objectives, and expected benefits were ambitious, specific, clear, and measurable providing management with clear accountabilities. BERL estimated that the SPATnz Programme would create between 480 and 1,100 jobs and add $204 to $485 million per year of "sales" to New Zealand's economy by 2026. This estimate was based on two scenarios where hatchery(s) supply 30,000 tonnes (Scenario 1) and 90,000 tonnes (Scenario 2). The economic benefits to New Zealand are estimated to be $81 to $193 million GDP by 2026.

The Programme has demonstrated the fundamental commercial benefits are above and beyond what was anticipated. SPATnz is now capable of producing ~ 30,000 GWT, which is estimated to be worth an additional $150 million per annum to the GSM industry at pre-Covid-19 prices (Sanford interviewee estimation).

Drivers for Innovation and Research

Farmed GSM was historically wholly dependent upon wild-caught spat. The large variation in retention and quality of wild-caught spat meant that the industry had limited control over the quantity and characteristics of its production, which varies year by year. Demand for spat was not as strong at the time the Business Case was written, however, since then consented marine farming space has increased (Table 4) and wild spat availability has significantly reduced. Current and consented hectares of mussel farms are ~15,000 ha with 58% of that area yet to be utilised (Table 4). Aquaculture New Zealand estimates that overall spat requirements will increase 70% by between 2020 and 2035. This in conjunction with plans to increase marine farm areas, including offshore farms, as identified or discussed in the Government's Aquaculture Strategy will increase demand for spat. Therefore, demand is estimated to outweigh supply for the foreseeable future.

Table 4. Current developed and consented hectares of mussel farms

At Sept 2019	Developed Mussel Farms (ha)	Consented for mussels (ha)	% utilised
Northland	43	119	36%
Auckland	134	948	14%
Waikato	1,450	1,750	83%
Bay of Plenty	820	3,800	22%
Tasman	468	2,200	21%
Marlborough	3,045	3,045	100%

Canterbury	166	3,000	6%
Southland	97	97	100%
	6,223	**14,959**	**42%**

Source: Aquaculture New Zealand

Growth, Supply and Quality of spat

The concept of selective breeding in aquaculture is not new. Researchers have been trying to rear GSM in hatcheries since the 1970s however larval stages were the barrier for many years. Data on the performance of the selectively bred mussels was limited to small scale trials with mussels on individual dropper ropes. Once the SPATnz Programme had developed solutions to larval rearing problems (Box 2), it developed methods for large scale spat production and a library of selectively bred mussel families.

Box 2
Overcoming Obstacles

Solving larval rearing problems was a major breakthrough for SPATnz. This was reported to be the greatest factor limiting production in the first 18 months of operation and the greatest impediment to programme success.

Major breeding gains were reported by growers of selectively bred hatchery spat as a positive outcome (see Table 5) including improvements in farm productivity (Box 3). The gains seen in Table 5 were averaged across ten experimental growing sites in Marlborough, or based on hundreds of commercial harvests.

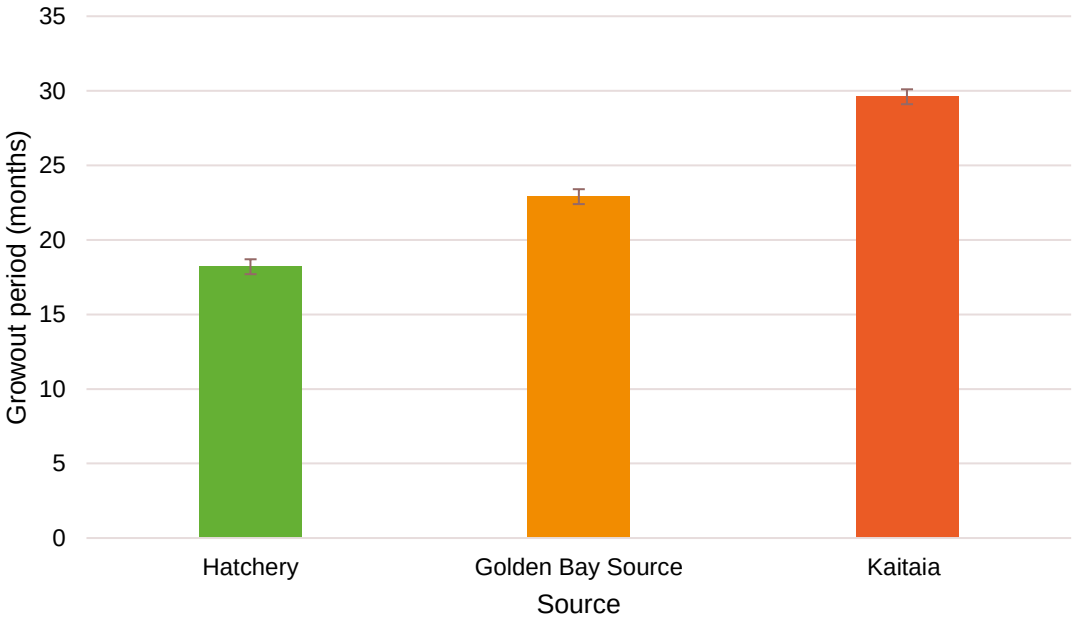

Figure 3. Growout periods of Hatchery, Golden Bay and Kaitaia mussels in 2017-19 commercial harvests landed in Havelock. Mean ± se, n= 135 to 925.

The quality of adult mussels from hatchery spat has also amazed growers and is another unintended positive outcome of the Programme. Mussels are growing to consistent sizes, and with less biofouling, are therefore easier to process using automatic mussel openers. The uniformity of mussel size generates further benefit through the reduction in numbers of small mussels lowering the cost of production as well as achieving a better price per kilogram.

Other benefits achieved include the ability to selectively breed favourable traits such as growth rates, shell strength and colour, and meat content. While mussel condition is harder to measure than growth, and to distil into a single trait, evidence shows that certain families offer better condition almost regardless of how it is measured.

Box 3 Growout:
An unexpected positive outcome

Growout periods have shown significant differences between mussel types with those for Golden Bay mussels being ~26% longer than hatchery mussels and those for Kaitaia mussels ~62% longer (~70-80% of current wild spat supply) (see Figure 3) and have delivered unexpected positive outcomes.

This has flow on benefits in the supply chain such as efficient use of farm space due to increased throughput and a greater kg/m yield.

In BERL's 2010 economic analysis, no value was assigned to the benefit of a scalable hatchery seed supply in enabling expansion of a spat constrained industry. While difficult to quantify, this benefit is clearly significant. Another major benefit from the SPATnz Programme is the ability to increase spat supply to meet growing demands from industry associated with the increase in new water space available for development in Golden Bay and Tasman Bay and other areas.

Table 5. Estimated gains from selectively bred hatchery mussels compared with a 70/30 mix of Kaitaia/Golden Bay wild-caught mussels. Estimates relate to the farm space required to produce 30,000 T/y of mussels with wild-caught mussels. 2010 estimates are updated for current mussel pricing. To estimate wider economic benefit, the BERL Report (2010) applied estimated revenue gains and other inputs to a model of the New Zealand economy to predict impact on GDP.

Item	BERL Report (2010)	With 2019 mussels/data	NOTES	With 2026 mussels/data	NOTES
	($ M)				
Faster growth increases crop	36.5	60.9	1	75.0	1
More kg per m	0	27.1	2	27.1	
Production loss from wild spat shortages	4.2	4.2	3	4.2	
Less water space occupied by seed	8.3	5.2	4	5.2	
Increased harvest windows	8.0	Requires commercial data	5	4.2	5

Reduction of small grade (lower value, higher cost) and extra smalls discarded	8.9	0.7	6	0.7	6
Increased meat yield	2.6	Requires commercial data	7	2.6	7
Higher factory throughput	0	Requires commercial data	8	4.2	8
Less wastage from broken shells	1.3	0	9	0	
Less fouling reduces costs	0.6	0.5	10	0.5	
Higher base price per kg	10.4	0	11	0	
Scalable see supply helps industry expand				Large	12
Total Revenue Gain	80.8	98.6		123.7	

1. Based on cycle times of 16.78 months. Gain will increase with ongoing selective breeding.
2. Based on yield of 7.50 kg/m at harvest, 15.93 tons per year per longline and cycle times of 16.78 months.
3. Wild spat supply shortages have worsened in recent years. Assumes 4% gain in production from more reliable spat supply.
4. Hatchery seed currently grows much faster and is produced monthly allowing more efficient space utilisation. Assumes seed space drops from 25% to 20% of farm space.
5. Programme results suggest this is likely, but data is not yet available.
6. Limited benefit at present because pricing for small grade is strong, and preliminary data suggest % extra small discards is low. Less small grade does reduce processing cost.
7. Meat yield is a heritable trait that can be improved with selective breeding.
8. Anecdotally the factory has higher throughput with hatchery mussels, but data are not yet available to verify this. Projected 2026 gain assumes 10% higher throughput.
9. In trials, the % broken was the same in hatchery mussels as wild mussels.
10. Based on data from grow-out trials, where wild mussels carried more fouling than hatchery.
11. Increased pricing due to greater consistency, branding, or higher value products is likely but no increase is assumed here.
12. The value of being able to scale up spat production to allow industry growth is difficult to quantify but a significant benefit of hatchery spat.

Shifting Gears: from Research Endeavours to Commercialisation

Science and commercialisation were well balanced throughout the course of the Programme. Interviewees shared how the Programme matured from a focus on science to an emphasis on commercial deployment. For the first five years, there were no sales of spat and in the sixth year of the programme spat was sold to Sanford at the market rate for Golden Bay wild-caught spat. By 2018, production for sales was separated from research and the production and sales continue to scale. This transition was important to the successful commercialisation of the Programme. Transition success was the

result of the adaptive approach applied to allow the scientific focus to continue on issue areas such as spat retention while increasing sales of hatchery spat.

Post the SPATnz PGP Programme funding, participants noted that the transition to full commercial scale will be challenging with ongoing research and development required, for example, adapting to local conditions at new hatchery locations.

Recommendation 1. SFF Futures programmes could use SPATnz as an exemplar to balance science research and commercialisation using an adaptive and systematic approach to problem solving. This may include having different types of agreements including Intellectual Property arrangements for different programmes (e.g. different exclusive periods).

3.2 Environmental Benefits

The Business Case projected that the Programme would maintain and enhance the environmental performance of the mussel industry by reducing the:

1. Environmental footprint (i.e. environmental impact broadly) of the industry per tonne of crop produced as a result of more crop grown per hectare of water space.
2. Biosecurity risk resulting from movement of wild spat (hatchery spat will be pest free).

Environmental footprint

The Programme has reduced the environmental footprint as described in the Business Case. Hatchery mussels reduced the amount of marine growth that accompanies the mussels to the factory by 72% compared with Kaitaia spat and 24% compared to Golden Bay spat. This reduced waste provides cost savings of approximately $0.5 million per annum on 30,000 GWT compared with a 70/30 mix of Kaitaia/Golden Bay spat (costs of harvest, transport to the factory, costs of factory sorting and disposal. Environmental benefits associated with this saving include reduced carbon emissions and a reduction in waste disposed off (58%) (Final Report).

Building resilience against biosecurity and climate change risks

Another positive outcome is the increased resilience against biosecurity and climate change risks.

Risks posed by pests and diseases had the ability to generate barriers to delivery of the programme benefits in numerous ways (Box 4). The Programme executed excellent risk management of biosecurity threats. This is corroborated by the independent mid-term review, which noted that biosecurity was the greatest risk to the Programme reporting that *"biosecurity has been built into the facility design and the hatchery operates best practice protocols"* (Mid-term Review, 2016).

Box 4
Biosecurity Risk

Biosecurity risk included risks to the operation of the hatchery itself and wider industry risks from biosecurity incursions (external to the hatchery itself).

Post-SPATnz PGP Programme, a representative of Cawthron noted that *"summer mortality is a particular issue that remains to be resolved, ideally before another hatchery is built to align production in parallel with animal health"*.

Other remaining biosecurity risks that are already being managed to a high standard include the presence of multiple tenants at the Aquaculture Park, and potential impacts on wild spat populations from selectively bred spat (particularly as scale increases).

The current single hatchery – even with effective biosecurity systems – also represents a vulnerability, as stated in the independent mid-term review and supported by interviewees in this review.

This is evident in the Programme reporting, collaborations with MPI, and by interviewees who described the adaptability and effectiveness of the biosecurity and risk management protocols. For example, the additional life-stage of mussels and switching from sea-based to land-based to increase

retention created new biosecurity risks. These risks were identified and effective ways to reduce these were implemented. The inclusion of the MPI Biosecurity Director on the PSG also provided technical capability from a governance perspective on such matters.

Other benefits included traits that build resilience against and provide opportunities for markets (including biosecurity, increase anti-inflammatory properties, and ocean acidification) and future proof the industry. In addition, GSM spat appear to be resilient to low pH events and studies have shown that once the mussels have formed their shells, they will grow in low pH conditions, albeit more slowly than in optimal conditions.

Looking forward, SPATnz and the wider industry will continue to face similar threats and it is important for the industry to continue to invest in research and development. In addition, building additional hatcheries that are geographically spread would add to the diversity and build redundancy, increasing resilience within the sector.

3.3 Innovation, Research, Risk and Reward

Research into the GSM industry in New Zealand was described by interviewees as inadequate prior to the SPATnz programme. This was corroborated by others who explained that the aquaculture industry is fragmented into production, research and development, and protection (food safety, protection, and animal health). A Cawthron interviewee described how critical it is for both companies and the government to be investors in research.

While investment and participation in the Programme were open to all industry players, *"Sanford was the sole industry participant willing to invest and bear risk in relation to the project"*. A key lesson learned here was the importance of having an industry partner, in this case, Sanford, willing to invest significant risk capital and to be embedded in the research. A number of interviewees commented that other industry participants have a more narrow and compartmentalised focus on compliance, applying for new farming space, food safety testing, monitoring, certification, and biosecurity.

Interviewees learned through this process that innovation is inherently high risk and expensive. Sharing that risk between public and private investors through partnerships such as the PGP is essential for accelerating growth. This Programme was imperative for GSM sector growth and by the end of the programme proved to be a wise investment for the participant.

3.4 Enabling Transition to Higher Value GSM Sector

Another significant benefit is the ability to selectively breed for traits such as bioactivity and support the growth of the very high value nutraceutical market from GSM. The programme focus from the outset was on supplying the market half-shell mussels but market research also explored nutraceutical opportunities. In 2017

Sanford acquired a mussel powder company and commenced developing its nutraceutical business. A Marine Extracts Centre now under development in Blenheim will increase Sanford's capacity to produce high value products from GSM and other species. This innovation will drive more demand for spat into the future.

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4.0 Findings: Governance, Collaboration, and Programme Management

4.1 Governance

The Programme Steering Group (PSG) was responsible for matters relating to approval of the annual plan and budget; the performance and variation to the Business Plan and contract; and, validating MPI's investment. Governance was highly effective, with reporting and decision making well managed, and the relationship with the Programme Manager was very strong. The PSG was led by an Independent Chair, which was noted by multiple interviewees as a positive element of the Programme. Risk management was highly effective and allowed the programme to adapt to mitigate risks over time. In addition, continuity of membership was a major benefit to the programme.

The PSG had a strong balance of skills (both technical and strategic) and level of representation in terms of management/decision making. A key learning here was having senior management from Sanford participating in the PSG. Interviewees universally supported the role of the MPI PGP Investment team and PSG representatives. There was a balanced emphasis placed on innovation and risk management by both the PSG and Programme Manager. Members from the PSG interviewed noted that the Programme Manager was challenged by Sanford and the PSG to take risks. This has led to greater outcomes than may have been anticipated.

Other factors attributing to the success of the PSG were that the governance skills required were met and workshops were arranged to set expectations from the start. Moreover, a key learning was the importance of the culture of the PSG that was described as being open and supportive with a SPATnz mindset rather than a self-interest mindset. Another key lesson learned was having an experienced, independent PSG Chair is critical to high risk, innovative programmes of this nature that receive both public and private funding. In addition, MPI PSG representatives were described as excellent, creative, with good technical capability, and positive contribution.

4.2 Programme Management

Effective and efficient leaders and partners

The Programme was exceptionally professionally managed, achieved what it set out to do with strong leadership with an outstanding high calibre research team. The Programme was a major success, and this was noted by all interviewees. A significant contributor to this was the leadership and support from the PGP, the Programme Manager, Sanford, Cawthron, and MPI. The Programme was under budget, spending only 87% ($22.6 million) of the $26 million budgeted. The budget was managed iteratively and adapted continuously.

A key lesson learned, identified by interviewees was the importance of "*picking the right people (as well as the right partners)*", *"you need the right people in there driving"* with the "*faith and vision*" to "*take the risk*" and "*see the project through*".

The support Sanford provided was highly valued by all interviewees (both in terms of leadership and resources). Moreover, having a vertically integrated company with resources (e.g. vessels, farms, processing factory) was a major benefit to the Programme. The commitment from Sanford provided positive momentum throughout the Programme.

The Programme Manager was essential to the Programme's success. Well-rounded skills in management and science, excellent communication, is a lesson for SFF Futures programmes. As an individual the Programme Manager was described as knowledgeable, a great leader, proactive, organised, an amazing person to work with, and someone who was humble.

Box 5: Adaptive management examples

In anticipation of bottlenecks and issues related to Project's 1 and 2, resources were earmarked for coming months/quarters in quarterly reports to the PSG: For example:

"summer is traditionally our most consistent season for larval rearing so if inconsistency returns in coming months, we may divert research effort to address this…

…The distribution of effort among the projects does not need to change substantially. I suggest that we divert about 30% of the Project 6 budget to Milestone 1.3.1 (Hatchery Process) to better match the effort required. If persistent difficulties with larval rearing arise in winter 2013, I will consider proposing extra effort on this key issue, probably at the expense of the market development timetable."
(Q3 Report 2012)

In 2016, the Outcome Logic Model was updated to reflect opportunities and roadblocks such as discontinuing project objectives such as ropes and the market research and also including additional benefits such as the supply of spat.

Changing specifications of the hatchery building including a modified pond system became more obvious further into the Programme.

By changing operations markedly, for example, introducing a new life stage for the mussels, SPATnz was able to increase spat retention up to ~40%. For the future, these key learnings around retention could be used for growing wild spat in a spat constrained market.

The culture of SPATnz was also integral to the success. The culture was created in the genesis of SPATnz where visionary scientists and commercial representatives came together and operationalised a vision and value proposition to MPI. The leadership and vision portrayed by all involved highlights the culture and willingness of MPI, Cawthron, and Sanford to collaborate.

Further lessons learned include project management and, in particular, being realistic with timeframes. Having clarity and clear decision making around issues and risks required solution and focus. Problem solving worked well *"when we had a problem, the reaction was quick and effective".*

The need to be flexible and to adapt was key to the success. Project management was adaptive in a number of areas (Box 5).

Overall, adaptiveness was fundamental to the innovative endeavour and the SPATnz Programme is evidence of how it overcame the larval rearing and retention bottlenecks.

Capability and Skills

A central part of the Programme was to *"deliver capability benefits by upskilling New Zealanders to develop and operate a shellfish hatchery of unprecedented international size for mussels, with associated world-leading selective breeding programmes"* (Business Case, 2010). There was a diversity of skills required to deliver the Programme. Overall, there was a good blend of science and commercialisation skills. Most employees had private sector experience which was noted as being beneficial. Human capability was earmarked in the mid-term review as a key risk where *"bespoke skills and intensive training that opens up SPATnz to loss of institutional knowledge and further investment should staff leave and require replacing."* However, this is continually managed through succession planning and having redundancy in each role.

At the Business Case stage, there were four to five people specialising in GSM hatchery technology in New Zealand. The Business Case anticipated a team of 15 people. Tertiary training was well executed by Nelson Marlborough Institute of Technology (NMIT) and SPATnz, including supporting trainees and employing graduates. Findings in the mid-term review of the Programme revealed how the Programme was valuable in training and creation of jobs and for the future of New Zealand's aquaculture and the development and retention of these skills in New Zealand.

Box 6:
BreedCo and Intellectual Property

BreedCo manages a breeding programme including hundreds of improved mussel families spanning up to several generations, and a database of all current and past families. BreedCo owns the IP relating to the genetics of the selectively bred mussel families used in the hatchery and all their records.

The genetics are a key driver for securing the on-farm productivity gains proven by the Programme. So, breeding IP is separate from SPATnz Programme IP, a model based on similar frameworks found in forestry for sharing IP. There are multiple opportunities for BreedCo post commercialisation of SPATnz's IP. BreedCo will derive revenue from the provision of broodstock, or a royalty on seed produced.

Staff from Cawthron at the formative stages of the Programme were knowledgeable and provided integral advice on the breeding strategy and reviewing the design and technology of hatchery processes. A Cawthron representative commented on the complementary skills between the two organisations, *"we do the [research] bit they can't do"*. The original breeding strategy adapted technology and IP from other Primary Industries in New Zealand (see Box 6). Capacity constraints for some specialist (quantitative genetics) skills remained an issue throughout the programme. For example, a quantitative geneticist's role has remained vacant since 2016.

4.3 Collaboration

Formal and informal collaboration was reported as a highlight of the Programme by interviewees. The mid-term reviewers also noted that the Programme had a number of active collaborations with other institutions undertaking related research (skippers, crew, growers, scientists, engineers, etc). Relationships and capability were built intensively throughout the course of the Programme. Continuity in SPATnz and Cawthron through low staff turnover was noted as a major factor contributing to the success. This retained the skills and history and developed essential goodwill within Programme Partners. The skills and knowledge acquired from SPATnz research are described in the mid-term review as having the potential to be applied to other shellfish species.

Sanford's partnership with Cawthron was effective; in part due to Sanford's willingness to invest alongside research providers. MPI teams worked well together with the partners and research providers and were decisive and structured in their engagement with the Programme. The MPI Investment team engaged internally as needed.

Recommendation 2: Future SFF Futures programmes to use SPATnz as an exemplar for programme management, governance, reporting, and risk management.

Recommendation 3: Future SFF Futures programmes should ensure consistency across how the PSG and Programme are resourced. This has provided benefits including collaboration, goodwill, trust, and retention of highly unique skills.

Recommendation 4: Future SFF Futures programmes should ensure a blend of technical and strategic skills on the PSG.

Recommendation 5: Future SFF Futures programmes should ensure that there are the tools, capability, and project management frameworks to be flexible and adapt for efficient problem solving which is characteristic of taking on innovative ventures.

5.0 Future Benefits and Opportunities

The benefits of the Programme are mostly driven by selective breeding gains and a scalable spat supply. The breeding benefits of the Programme have already exceeded those identified in the original Business Case. The growth advantage of hatchery spat has already exceeded expectations anticipated for 2026 and the additional crop yield at harvest was not anticipated. SPATnz also has plans to increase current production through expansion of the hatchery and by investing in an additional hatchery within the next five years.

While spat production met targets, there remain potential benefits yet to be proven/quantified, including increased harvest period through avoidance of crop loss in winter.

Opportunities for Commercialisation

The SPATnz PGP Programme has led *"to major fundamental commercial benefits that were beyond and above that were anticipated including the growth rate and quality of the mussels"*. The future opportunity for the entire GSM industry is to realise the potential of this Programme for the rest of New Zealand.

The Exclusivity Period and Intellectual Property

The PGP funding agreement grants SPATnz exclusive rights to utilise the Intellectual Property (IP) that has been developed for five years post completion of the Programme (the Exclusive Period). Following the Exclusive Period, SPATnz has to meet the obligations of the PGP Programme Agreement, to:

a) Actively seek new investors to expand SPATnz's existing facility or build a new facility on an alternative site, to meet the New Zealand GSM industry demand for selectively bred spat; and,
b) Licence the Commercial Intellectual Property Rights, on the IP Commercialisation Terms, to other industry participants that choose to build a shellfish hatchery independent of SPATnz's hatchery.

SPATnz commissioned a report to provide advice to assist the PSG in developing the IP Commercialisation Terms that could apply at the end of the five-year Exclusive Period. The report identifies four commercialisation outcomes:

1) SPATnz sells spat to other market participants.
2) Co-investment is sought for expanding the current facility or building a new facility. This could occur via issuing shares in SPATnz or setting up a new company in which SPATnz/Sanford and other market participants are shareholders.
3) Licensing SPATnz's technology to other market participants wishing to establish a hatchery.
4) A combination of co-investment and licensing occurs.

The report also provided guidance on a fair commercial price at which spat could be sold.

The price for hatchery spat will vary year on year based on supply and demand factors (Box 7).

Due to the nation-wide need for spat, there is a concern (around access and wider benefits for the industry) from some interviewees who are not participants in SPATnz. Further, the key element of IP from the SPATnz Programme is the methods used to produce mussel spat reliably at scale. The IP must be offered to third oarties under license at the end of the Exclusive Period.

Box 7 Demand Factors

Factors affecting demand for spat include:

- the availability of wild caught spat;
- realised performance gains from hatchery spat;
- annual spat production levels across all hatchery operators; and
- biosecurity risks.

Expansion to meet increasing industry demand

The Programme concluded at the end of October 2019. For the remainder of the Exclusive Period, the growth of SPATnz appears likely to be limited to expanding the existing site and an additional site. Given the time taken to build hatcheries, capacity will remain a constraint on the very high demand for hatchery spat in New Zealand for some years.

About 58% of current consented mussel farm water space is presently unutilised. At the current annual production of 90,000 tonnes, if developed water space was seeded with hatchery spat, then industry production could increase to ~179,000 tonnes per annum - equivalent to approximately six hatcheries the size of SPATnz's Nelson facility (PwC, 2020).

The Annual Plan 2018-19 sets out SPATnz's commercialisation pathway for the short-term. It involves:

- BreedCo developing improved strains of GSM in close consultation with the industry
- SPATnz to access broodstock from these strains to produce commercial quantities of improved spat for Sanford and the dozens of mussel farming companies that Sanford processes mussels for
- Existing SPATnz customers will take all of the output from the current hatchery at current capacity.

The demand for additional hatcheries is clear, with available and consented water space roughly tripling the area available for mussel farming.

A New Zealand Spat strategy is being developed by the sector and will seek to increase the scale of production to scale up SPATnz to quickly deliver the greatest volume of spat.

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Other ventures

A Sanford respondent noted the breeding component of the programme was a "quantum leap" however that this just "scratched the surface" of what may be possible. Understanding the breeding process of mussels and how to breed higher bioactivity for anti-inflammatory properties was discussed as a future focus for SPATnz.

6.0 Lessons Learned

Programme Area	Key Lesson Learned
Governance, Collaboration, and Programme Management	Having an experienced independent PSG Chair with strong leadership. Senior management from Sanford attending meetings who understood the industry and operations. Having clarity around what the issues and risks were that required solution and focus. The importance of having the right people, the right skills, and culture within the Programme and PSG The need to be flexible, adaptive, and realistic with timeframes to cater for unexpected challenges.
IP and Commercialisation	Effectively managing the transition from research to commercialisation to maximise benefits.

7.0 Conclusions

The SPATnz Programme is already accruing significant benefits and the wider mussel industry will be the ultimate beneficiary. There is a great deal of potential for further research and commercialisation. This includes closing the winter cycle, identifying new markets, expansion including extension of the existing hatchery and building new hatcheries. There is also opportunity to increase productivity of wild spat through the key learnings from spat retention. Sanford is developing its future business plan for SPATnz within and beyond the Exclusivity Period. This is focussed on expansion and increasing capacity to meet demand.

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Appendix One: Terms of Reference

PRIMARY GROWTH PARTNERSHIP
EVALUATION OF THE SPATnz PROGRAMME
TERMS OF REFERENCE

PURPOSE

This document sets out the Terms of Reference (TOR) for an independent evaluation of the Shellfish Production and Technology (SPATnz) Programme (the Programme).

The TOR will be used when:

- Briefing, selecting and contracting an independent reviewer (The Reviewer); and
- Reviewing and accepting the Reviewer's report.

INTRODUCTION

The evaluation is commissioned by the Ministry for Primary Industries' (MPI) Sustainable Food and Fibre Futures team. It focuses on the achievements and expected outcomes from the SPATnz Primary Growth Partnership (PGP) programme.

It will also review the programme's execution and governance and identify any lessons from the Programme that would benefit other MPI investment programmes.

BACKGROUND

Primary Growth Partnership (PGP)

The Ministry for Primary Industries' (MPI) Primary Growth Partnership (PGP) has co-invested with primary industry partners in long-term, sustainable, innovation programmes. The goal of the PGP has been to deliver long-term economic growth and sustainability across New Zealand's primary industries.

These programmes are helping industry to increase their levels of market-led, high value product development, and farm improvement to lift productivity and profitability. Programmes have also yielded environmental sustainability, social and regional economic benefits.

PGP has encouraged more private investment in research and development in New Zealand's primary sector and shares the risk inherent in ambitious, large-scale transformational initiatives which would not proceed or would proceed much more slowly without government involvement.

The PGP and Sustainable Farming Fund (SFF) have now been combined and rebranded as Sustainable Food and Fibre Futures (SFF Futures). While the original PGP

criteria will remain, under SFF Futures a greater focus will be given to environmental sustainability and multi-partner programmes.

SPATnz Programme

The SPATnz programme (Programme) was a co-investment by Shellfish Production and Technology New Zealand Limited (SPATnz), a subsidiary of Sanford Ltd (Sanford), and MPI.

Because of the reliance on wild-caught spat, New Zealand's Greenshell™ mussel industry struggled to realise its full potential and to deliver a consistent supply of mussels with the characteristics demanded by premium markets. Wild spat sources allow little control over the timing and quantity of spat supply or the characteristics of the crop. The Programme was designed to domesticate the Greenshell™ mussel, and develop a wide range of selectively bred, high-performing breeds for the industry.

Objectives

The SPATnz programme involved research into selective breeding of GSM in captivity in order to control the quality of the spat crop and ensure a reliable, consistent and year-round supply. It also aimed at developing hatchery technology to breed and hatch improved stock.

The programme aimed to deliver:

- Knowledge and capability to produce hatchery-reared GSM at a commercial scale;
- Selectively bred spat of GSM with enhanced production and market characteristics; and
- Hatchery and sea-based nursery infrastructure.

The target for the Programme is increase of up to $81 million in direct economic benefit (GDP) by 2026. If the technology is to be adopted by GSM industry as a whole, GDP increase may be up by $193 million.

An independent progress review of the Programme was undertaken in 2016. These documents, including final programme report will be provided as part of the evaluation process.

The expected outcomes for the Programme are included in the Outcome Logic Model and KPIs which can be seen in the public version of the programme's Final Report, all of which can be viewed via these links:

https://www.mpi.govt.nz/dmsdocument/3126-outcome-logic-for-spatnz-programme-2012-2019-updated-august-2016

Projects

The programme carried out a range of mutually supporting projects to drive the transformation from wild caught spat NZ's GSM to selectively bred, high-performing breeds. These included:

Advanced Broodstock / Seed for GSM – hatchery technology and selective breeding;

- Sea Based nursery production systems;
- Grow-out of selected GSM;
- Processing of selected GSM;
- Expanding market opportunities for GSM; and
- Programme management.

Further background on this completed programme is available at the link which follows:

https://www.mpi.govt.nz/funding-and-programmes/sustainable-food-and-fibre-futures/primary-growth-partnership/current-pgp-programmes/spatnz/

SCOPE

In Scope

The evaluation will primarily assess the achievements and expected outcomes from the Programme with a strong focus on key measures in the Outcome Logic Model. As part of the evaluation the consultants will review SPATnz' performance against the Programme's KPIs and its assessment of economic benefits to New Zealand and to the New Zealand mussel industry, which are included the Final Programme Report.

The evaluation will also review programme management and governance and draw any lessons from the Programme that would benefit the Programme partners, other programmes and/or the SFF Futures portfolio going forward.

Questions

There are three key Evaluation Questions that need to be answered to inform MPI whether it can be confident that the forecast benefits of the Programme will be achieved:

1. Outcomes - what has been accomplished by the Programme so far and what are its benefits to New Zealand?
2. Execution - how well was the Programme executed?
3. Lessons Learned- what are the lessons from the Programme and implications for other programmes and to SFF Futures as a whole?

Out of Scope

The scope of the evaluation does not include the rationale for investing in the Programme and or assessment of the PGP model or criteria.

TERMS OF REFERENCE

Please view the following table:

Description	Evaluation Questions
1. Evaluate what has been achieved by the Programme, and the benefits that have been delivered and are forecast to be delivered for New Zealand.	**OUTCOMES** What has been achieved by the Programme and what are the benefits to New Zealand? a. What progress has been made towards achieving the Programme's intended short, medium and long-term outcomes as set out in the contract and the Outcome Logic Model attached? b. Has the Programme delivered significant beneficial outcomes to the Programme partners, the broader industry, and to New Zealand? c. Will MPI and the Partners get what they expected when committing to invest in the Programme? Are there significant differences to the range or scale of benefits or the timing of their realisation? d. Have there been significant unintended outcomes (positive or negative) from the Programme to date? Are there any anticipated that will requiring monitoring in the future? e. Can MPI have confidence that the economic benefits estimated to have been realised and forecasted to be delivered are based on sound assumptions using robust methodologies? In particular, comment on the consideration of the counterfactual scenario. f. Do the Partners have the planning and resources in place to achieve the projected future outcomes and benefits? g. Has MPI's investment in the programme been worthwhile?
2. How well has the Programme been implemented? (e.g.	**EXECUTION** a. Did the Programme secure the governance, programme management, technical expertise and

annual plans effectively adapted to changing circumstances to increase the likelihood of benefits being achieved)	resources needed to address the technical and strategic challenges faced? b. Were the structure, systems and management effective in delivering and adjusting the work plan as required? c. How well did the Programme do in achieving its milestones and achievement measures? d. How effective was the Programme's governance? e. Were the recommendations from internal and external reviews of the Programme considered and adopted accordingly?
3. What are the lessons to be learnt from the Programme and implications for investment in other programmes	**LESSONS LEARNED** a. What were the main lessons learned from the Programme? In particular, lessons from the findings on the execution of the Programme and delivery of the targeted outcomes and benefits? b. What are the suggestions for improvement, if any, for MPI and the Partners? c. How can MPI support the Partners to maximise the realisation of the financial, economic, spillover and public good benefits identified during the life of the Programme?

EVALUATION PROCESS

Team

The evaluation will be carried out by an independent consulting firm appointed by MPI. The selected consulting firm will manage and coordinate the evaluation team, gather information and data, conduct analysis and produce a report on the overall findings which reflects its experience, analysis and judgement.

The firm's team would need to include the following subject matter expertise. This is shown as residing in two individuals but could be spread differently or more widely:

- A consultant and/or aquaculture expert with a practical understanding of the GSM industry, the biology of GSM growth and the impact of selective breeding on GSM and the mussel industry. An up-to-date knowledge of extension and adoption behaviour among mussel growers would be helpful.
- A primary sector economist with expertise and experience in understanding investment returns from research and development, market commercial behaviour among growers, cost-benefit analysis, and net present value projections. Knowledge of the mussel industry would be helpful.

If required, MPI reserves the right to nominate industry practice subject matter experts in specific areas. SMEs would work as part of the team under the direction of the Lead Reviewer.

Methodology

The evaluation will be done by reviewing key programme documents, conducting stakeholder interviews, considering industry information from outside the programme and the analysis of all these inputs. The Final Programme Report is a key reference document.

The evaluators are expected to use independent data when analysing industry trends wherever possible and where such data is available. They will test the assumptions contained in the Final Programme Report in particular and seek to corroborate or validate these and make informed judgements.

The Investment Manager from MPI will provide key liaison support for supplying documents and for arranging interviews.

Desk research

Documents to be examined in the review will include:

- Final Programme Report
- Annual Plans and Quarterly Reports
- Outcome Logic Model which lists expected outcomes

- Short- and Medium-term outcome measures/KPIs with performance data collected
- Original Business Case
- Independent Progress Review Report
- Other reports and/or evaluations produced to inform the Programme

Interviews

Phone or face to face interviews to be held with:

- Programme Manager and key programme staff
- CEO of Sanford
- MPI Investment Manager
- Chair and members of Programme Steering Group
- Director of MPI Investment Programmes
- Chair of Investment Advisory Panel (or a delegated panellist)
- Growers stakeholders in SPATnz who have been exposed to the programme
- Research and industry partners of SPATnz
- Industry insiders not involved in the Programme

ACTIVITIES AND DELIVERABLES

- **Updated evaluation plan** based on an establishment meeting with MPI to provide supporting information, agree stakeholder interviews and finalise delivery timelines.
- **Implementation** of the evaluation plan, including review of programme documentation, stakeholder interviews, additional data collection and analysis.
- **Discussion** of the evaluation findings with MPI staff before the report is written.
- Face-to-face **presentation** of the evaluation findings to MPI staff, and SPATnz.
- A full, confidential **evaluation report** for MPI and SPATnz.
- A **public summary version of the evaluation report, (**with commercially sensitive information removed) approved by the MPI Director of Investment Programmes and SPATnz, suitable for publication on MPI's SFF Futures webpage.

TIMELINES

The table below is a guide and may be modified in proposals submitted after candidates
have considered the work more closely in relation to their own experience and commitments. The evaluation plan referred to above, agreed with MPI, may result in a further refinement
of the timetable.

Work	Deadline
Proposal due and delivered to MPI	Tues 11 February 2020
Consultant selection and contract signed	Wed 19 February
Final evaluation plan completed for MPI	Fri 28 February
Evaluation work completed	Wed 22 April
Discussion of evaluation findings with MPI	Fri 1 May
Draft reports due with MPI	Fri 15 May
MPI feedback on draft reports	Fri 29 May
Final Reports Due	Mon 15 June 2020

CONFIDENTIALITY

Members of the evaluation team will receive information that may include confidential, contentious or commercially sensitive details. All relevant information will be put before the evaluation team for its members to consider and communicate about issues freely and frankly within the context of the work.

The information supplied to the evaluation team and the findings from the evaluation, and any subsequent discussions, must remain confidential to MPI, SPATnz and the evaluation team. Members of the evaluation team will sign a Confidentiality Agreement prior to receiving information for the evaluation.

Appendix Two: List of Interviewees

Name	Organisation	Role
Rodney Roberts	SPATnz	Programme Manager
Andy Day	SPATnz	Team Leader Sea-Based Research
Rob Cooke	SPATnz	Team Leader Algal Production
Dan McCall	SPATnz	Operations Manager
Garry Wilson	Programme Governance Group	Chair
Clement Chia	Sanford	Chief Operating Officer
Ted Culley	Sanford	General Manager Aquaculture
Humayun Khan	Ministry for Primary Industries	Investment Manager
Steve Penno	Ministry for Primary Industries	Director, Investment Programmes

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Barry Brooke	SFF Futures Investment Advisory Panel	Member
Bruce Hearn	APEX Marine Farm	Grower
Charles Eason	Cawthron	Chief Executive Officer
Serean Adams	Cawthron	Aquaculture Group Leader
Nick King	Cawthron	Aquaculture Scientist
Gary Hooper	Aquaculture New Zealand	Chief Executive Officer
Dan Lees	Ministry of Primary Industries	Manager, Aquaculture
Jake Bartrom	Coromandel Marine Farmers Association	