FINAL REPORT

An Impact Assessment of Investment in FRDC Project 2016-235:

Improving post-harvest survivability of southern rock lobster in a changing environment

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In submitting this report, the researcher has agreed to FRDC publishing this material in its edited form.

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- Quinn Fitzgibbon, Deputy Director, ARC Research Hub for Commercial Development of Rock Lobster Culture Systems

Abbreviations

API	Application Programming Interface
CBA	Cost-Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
DAWR	Department of Agriculture and Water Resources
FRDC	Fisheries Research and Development Corporation
MIRR	Modified Internal Rate of Return
OCS	Office of the Chief Scientist
R&D	Research and Development
RD&E	Research, Development and Extension
SARLAC	South Australian Rock Lobster Advisory Council
SRL	Southern Rock Lobster
TRLPA	Tasmanian Rock Lobster Processors Association

Executive Summary

Fisheries Research and Development Corporation (FRDC) project 2016-235 addressed the high level of pre-export mortality (in excess of 10% per day in some facilities) of the Australian Southern Rock Lobster (SRL). This was resulting in severe financial losses to the exporting industry in 2016. Financial losses to the industry included having to sell lobsters earlier then otherwise at reduced prices, as well as post export mortality resulting in damage to the reputation of the Australian SRL export industry.

The project set out to better understand the causes of the high mortality rates and find solutions to better manage pre-export activities.

The Australian SRL Industry is a significant Australian fishing industry. The industry contributes around $250 million in landed seafood value to the Australian economy each year (SRL, 2021). The industry operates across three states (South Australia, Tasmania, and Victoria) and harvests over 3,000 tonnes of lobster each year. The export market for live SRL is significant and relies on the holding of live lobsters for varying periods before export to combat fluctuations in export market demand.

Unexplained high export mortality necessitated an effort to understand the cause (or causes), and seek solutions to remedy the situation. A range of issues were addressed in the project including lobster biochemical, immunology, microbiological and pathological studies, industry surveys including at holding facilities, and water quality testing assessments. Extension of information was provided to industry via the development of a best practice guide and best practice workshops. A series of recommendations were made in the final project report.

It is understood that a number of companies have already made efforts to improve operations; for example, project recommendations associated with the frequency of water testing and monitoring (use of test kits) have been adopted at many industry sites. Also, a number of industry systems and procedural changes have addressed the recommendations for the use of the lactate and other assessment tools to provide superior evaluation methods for determining the condition and suitability of lobsters for holding and live export. However, work is still proceeding to better validate the lactate system as part of a current FRDC project.

One company reported that in 2018/19 the company experienced a 50% reduction in mortality that can be attributed to improved practices. Also, there have been fewer industry reports of mortality concern. However, the proportion of the industry that has already experienced a reduction in SRL morbidity and deaths due to the information provided by the project is difficult to estimate. Nonetheless, all industry participants that have made changes have seen reductions in morbidity and deaths.

There were some additional costs incurred by industry in relation to minimising morbidity and deaths (e.g. increased water quality testing costs, determining lobster condition, increased holding costs). However, any additional costs were well covered by the savings resulting from reduced mortality.

The total funding for the project over four years was $1.51 million in present value terms. Given the assumptions made, the benefits accruing to the investment were estimated to be valued at $8.81 million in present value terms. This gave a net present value of $7.30 million, a benefit-cost ratio of 5.83 to 1, an internal rate of return of 49.1%, and a modified internal rate of return of 14.6%. As several of the minor impacts identified were not valued, the investment criteria as provided by the benefits valued could be an underestimate the true investment performance.

Introduction

The Fisheries Research and Development Corporation (FRDC) required an annual series of impact assessments to be carried out on a sample of completed investments from the FRDC research, development, and extension (RD&E) portfolio. The assessments were required to meet the following FRDC evaluation reporting requirements:

- Reporting against the FRDC 2015-2020 RD&E Plan and the Evaluation Framework associated with FRDC's Statutory Funding Agreement with the Commonwealth Government.
- Annual Reporting to FRDC funding partners and other stakeholders.
- Reporting to the Council of Rural Research and Development Corporations (CRRDC).
- Reporting RD&E impact and performance to FRDC levy payers and other fisheries and aquaculture stakeholders as well as the broader Australian community.

In April 2017, FRDC commissioned Agtrans Pty Ltd (Agtrans) to undertake the annual impact assessments for RD&E projects funded under the FRDC 2015-2020 RD&E Plan and completed in the years ended 30 June 2016 to 2020 (FRDC Project 2016-134). Between 2016/17 and 2020/21, four series of annual impact assessments were completed. Each of the four series of assessments included a set of 20 randomly selected FRDC RD&E investments as well as an aggregate analysis across all 20 investments evaluated in each year. Published reports for the annual FRDC evaluations can be found at: https://www.frdc.com.au/frdc-project-impact-assessments-benefits-research.

The fifth and final series of impact assessments under Project 2016-134 was for a set of FRDC RD&E investments completed in the year ended 30 June 2020, the final year of the FRDC 2015-2020 RD&E Plan. As in previous years, the fifth series of impact assessments included 20 randomly selected FRDC RD&E investments. The 20 investments had a total value of approximately $5.30 million (nominal FRDC investment) and were selected from an overall population of 81 FRDC investments worth an estimated $17.66 million (nominal FRDC investment) where a final deliverable had been submitted in the 2019/20 financial year.

The 20 RD&E investments were selected through a stratified, random sampling process such that investments chosen spanned all five FRDC Programs (Environment, Industry, Communities, People and Adoption), represented approximately 30.0% of the total FRDC RD&E investment in the overall population (in nominal terms), and included a selection of small, medium, and large FRDC investments (total nominal FRDC investment of $\leq$ $50.000, $50,001 to $250,000, and > $250,000 respectively).

Project 2016-235*: Improving post-harvest survivability of southern rock lobster in a changing environment* was randomly selected as one of the 20 RD&E investments completed in 2019/20 for evaluation in the fifth series of annual impact assessments (2019/20 sample). The current report presents the Project 2016-235 analysis and findings.

Method

The annual impact assessments of FRDC RD&E investments followed general evaluation guidelines that are now well entrenched within the Australian primary industry research sector including Research and Development Corporations, Cooperative Research Centres, State Departments of Agriculture, and some universities. The approach includes both qualitative and quantitative assessment components that are in accord with the current guidelines for impact assessment published by the CRRDC (CRRDC, 2018).

The evaluation process utilised an input to impact continuum RD&E project inputs (costs), objectives, activities, and outputs were briefly described and documented. Actual and expected outcomes, and any actual and/or potential future impacts (positive and/or negative) associated with project outcomes then were identified and described. The principal economic, environmental, and social impacts were then summarised in a triple bottom line framework and validated through consultation with expert personnel and review of published literature.

Once impacts were identified and validated, an assessment then was made about whether to quantify/value any of the impacts in monetary terms as part of the project-level analysis. The decision to value an impact identified was based on:

- Data availability and information necessary to form credible valuation assumptions,
- The complexity of the relevant valuation methods applicable given project resources,
- The likely magnitude of the impact and/or the expected relative value of the impact compared to other impacts identified, and
- The strength of the linkages between the RD&E investment and the impact identified.

Where one or more of the identified impacts were selected for valuation, the impact assessment used cost-benefit analysis (CBA) as a principal tool. The impacts valued therefore were deemed to represent the principal benefits delivered by the project investment. However, as not all impacts were valued (based on the selection criteria), the investment criteria estimated for the project investment evaluated are likely to represent an underestimate of the true performance of the FRDC project.

The qualitative and quantitative analysis processes, data sources, assumptions, specific valuation frameworks (where applicable), and evaluation results were clearly documented and then integrated into a written report.

Project Background

Background

The Australian Southern Rock Lobster Industry (SRL) is a significant Australian fishing industry. The industry contributes around $250 million in landed seafood value to the Australian economy each year (SRL, 2021). The industry operates across three states (South Australia, Tasmania and Victoria) and harvests over 3,000 tonnes of lobster each year. The export market for live SRL is significant and relies on the holding of live lobsters for varying periods before export to combat fluctuations in export market demand.

In 2016, levels of pre-export mortality of SRL were severe (in excess of 10% per day in some facilities), with significant financial losses to the exporting industry estimated at hundreds of thousands dollars per annum through physical losses and price reductions. Financial losses to the industry included:

- having to sell lobsters earlier then otherwise at reduced prices, and
- significant post-export mortality damaging the Australian SRL industry reputation.

Rationale for Project 2016-235

The pre-export mortality situation in 2016 resulted in the industry making an effort to understand the cause or causes of the high mortality rates and to seek solutions to remedy the situation. FRDC project 2016-235 was funded to investigate the SRL pre-export high mortality issue.

Project Details

Summary

Project Code: 2016-235

Title: *Improving post-harvest survivability of southern rock lobster in a changing environment*

Research Organisation: University of Tasmania

Principal Investigator: Quinn Fitzgibbon, Research Fellow, Institute for Marine & Antarctic Studies, in conjunction with the School of Animal and Veterinary Sciences, University of Adelaide

Period of Funding: November 2016 to November 2018

FRDC Program Allocation: Industry 100%

Objectives

1. Undertake an epidemiological investigation to describe the magnitude of the mortality event and to identify potential environmental and management risk factor(s) associated with increased mortality.
2. Examine the underlying physiological processes or mechanisms resulting in lobster mortality and potential links with marine biotoxins.
3. To review the pathology from both the Tasmanian and South Australian mortality events during the 2016 season as well as further characterisation of any significant pathologies (e.g. antennule gland changes) observed in these investigations as well as further pathological investigations for the 2017 season.

Logical Framework

Table 1 provides a description of the project in a logical framework developed for the evaluation.

Table 1: Logical Framework for FRDC Project 2016-235

Activities	<u>Lobster biochemical studies</u> • The studies compared the physiological status of healthy and moribund lobsters to see if the underlying cause of mortality could be identified. • The biochemistry studies covered electrolytes, minerals, ions, metabolites and enzymes. <u>Immunology studies</u> • The immunology studies addressed the immune response of healthy and moribund lobsters to identify any disease infections. • This activity included the development of new immunological methodologies. <u>Survey addressing sub-optimal survival and associated risk factors</u> • An industry-wide survey was undertaken, and addressed risk factors associated with management and capacity. • The survey included visits to holding facilities and face to face interviews with manager/owners. <u>Studies at holding facilities</u> • An investigation of batch-holding factors influencing survival was carried out in 2016-17 at two industry-volunteered holding facilities.

	Microbiological assessments • Microbiological diagnostic studies were undertaken of SRL that showed morbidity or mortality. Investigation of pathologies • A study was undertaken to investigate whether there was a common pathology occurring in moribund SRLs. Health assessment refinements • Clinical chemistry studies were conducted. Water quality testing assessments • A range of water quality testing approaches was conducted; these considered both accuracy and costs. Evaluation of a hand-held lactate meter • As lactate builds up in SRL in response to stressors, measuring lactate is a useful diagnostic marker for stress, and results could be used to identify and reduce stress. • A hand-held lactate meter was trialled to assess its potential for use in SRL monitoring and management. Development of a best practice guide • A SRL best practice guide was developed to standardise the optimum handling and processing of SRL from initial handling to land transport, emersion periods, holding and air freight transport. Best practice workshops • A series of workshops were held to inform industry participants of the project findings and to receive industry views on future R&D required.
Outputs	Lobster biochemical studies • The biochemistry studies showed that, while there were significant differences between all sample animals, there was no clear difference between lobsters experiencing mortality and the group of lobsters with no mortality. • The conclusion was made from the biochemical studies that the mortalities were not due to a single pathogen. Immunology studies • The immunological study found that some lobsters were moribund for non-infectious reasons, such as inappropriate water quality or handling practices. Survey addressing sub-optimal survival and associated risk factors • The industry survey found that sub-optimal survival was reported in nearly half of the facilities surveyed. • The survey found a wide range of holding practices, and that facilities with intensive stocking management were correlated with an increased risk of lower survival rates. Studies at holding facilities • The studies found that sub-optimal survival was associated with transport time and distance. • Also, the holding facility studies reported that sub-optimal survival was greatest in the warmer months, as well as being correlated with lobster size, colour and stocking volume. Microbiological assessments

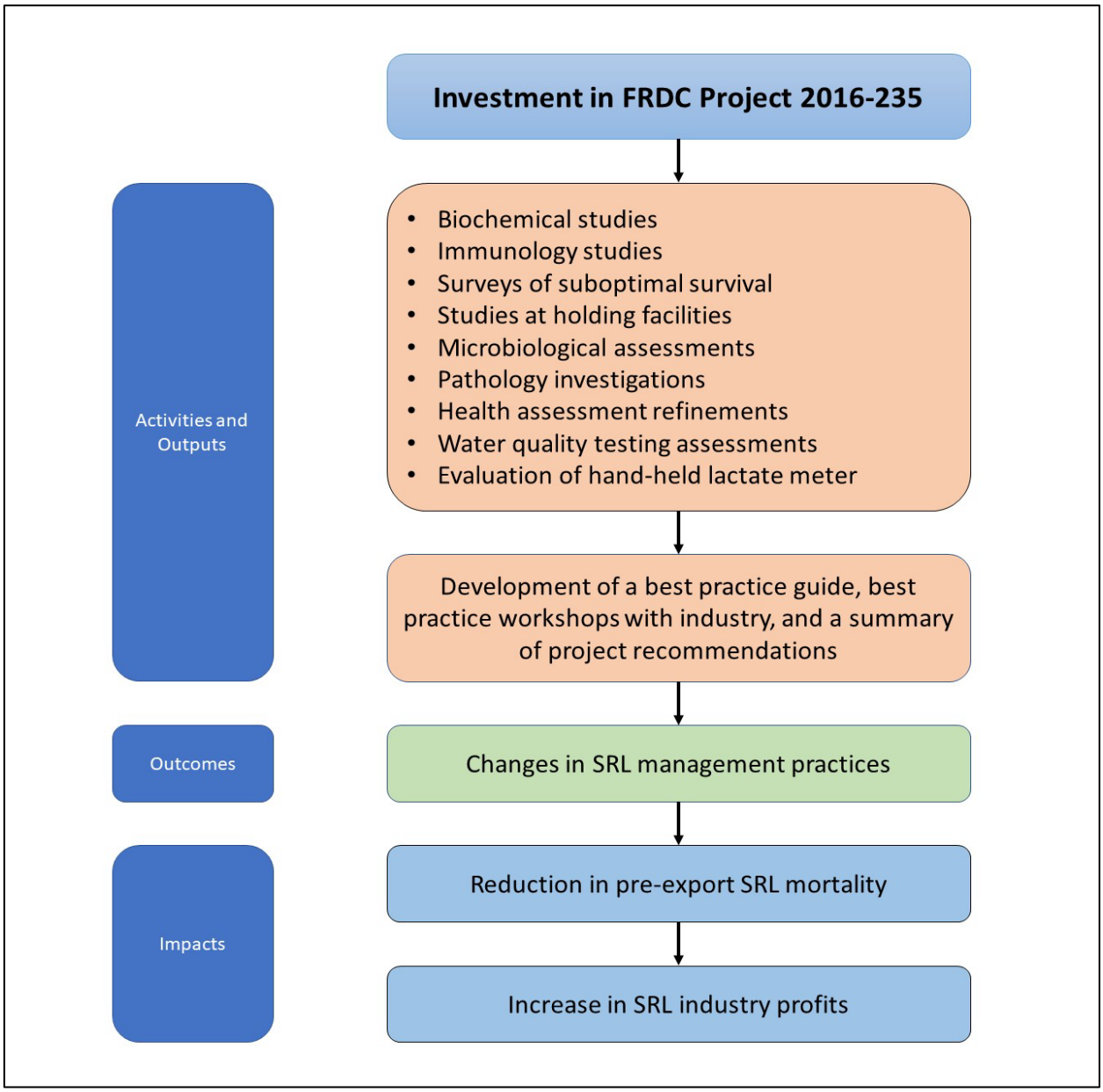
	• Microbiological diagnostic studies found *Vibrio tapetis* in a number of cases; however, there was no significant association between the *Vibrio tapetis* and morbidity and mortality. <u>Investigation of pathologies</u> • The pathologies investigation found that there was no common pathology with moribund SRLs observed across states and facilities. <u>Health assessment refinements</u> • The clinical chemistry studies found that tissue enzyme activity of SRL resembled that of terrestrial vertebrates and other crustaceans. <u>Water quality testing assessments</u> • The water quality findings showed that API (application programming interface) test kits were easy to use, economic and were a moderately accurate tool for regular water quality analysis. For greater accuracy and precision, the spectrophotometers offered highly robust results. • Recommendations on testing protocols were made to provide a framework for developing improved water monitoring regimes. <u>Evaluation of a hand-held lactate meter</u> • As measuring lactate was a useful diagnostic marker for stress, the project concluded that hand-held lactate meters were a useful and practical tool to measure the stress condition of the lobster at any time during handling and transport. <u>Development of a best practice guide</u> • The guide was developed to standardise the optimum handling and processing of SRL from initial handling to land transport, emersion periods, holding and air freight transport. <u>Best practice workshops</u> • Presentations were made in 2018 to Best Practice Workshops held in Hobart and Mt Gambier. • The workshops covered best management practices, as well as the water quality management tools and the stress-measuring lactate meter. • The workshops also gathered information regarding industry concerns and views on future R&D priorities. <u>Summary of project recommendations to improve industry practices</u> • Post capture transport, particularly on land dry transport procedures • Post transport recovery and purging procedures • Holding facility aquaculture systems • Water quality monitoring and maintenance • Live lobster handling procedures • Data collection and stock traceability • Stock quality assessments
Outcomes	• The project recommendations were received by the SRL Clean Green program (Quinn Fitzgibbon, pers. comm., 2022). • It is understood from the final project report that a number of SRL companies have already made efforts to improve operations. • For example, project recommendations associated with the frequency of water testing and monitoring (use of test kits) have been adopted at many industry sites (Michael Blake, pers. comm., 2022).

	• Also, several industry systems and procedural changes have accepted the recommendations for use of the lactate meter and other assessment tools to provide superior evaluation methods for determining the condition and suitability of lobsters for holding and live export (Michael Blake, pers. comm. 2022). However, work is still proceeding to better validate the lactate system as part of a current FRDC project examining the lobster fishing industry sector Quinn Fitzgibbon, pers. comm., 2022). • More broadly, one company reported that in 2018/19 the company has experienced a 50% reduction in mortality that can be attributed to improved practices. Also, there have been fewer industry reports of mortality concern (Quinn Fitzgibbon, pers. comm., 2022). • The proportion of the industry that has already experienced a reduction in SRL morbidity and deaths due to the information provided by the project is difficult to estimate. However, all industry participants that have made changes have seen reductions in morbidity and deaths (Michael Blake, pers. comm., pers. comm., 2022). • Estimates of the additional costs incurred by industry in relation to minimising morbidity and deaths (e.g. increased water quality testing costs, determining lobster condition, increased holding costs) are not readily available. However, most costs were one-off and not ongoing; any additional costs were well covered by the savings in mortality (Michael Blake, pers. comm., 2022).
Impacts	Impacts and potential impacts include: • A reduction in future financial export losses of live SRL due to adoption of improved water quality monitoring and handling practices. • Increased market resilience through improved product quality. • Increased costs of water monitoring and measurement/detection of stress conditions. • Reduced post-export mortality that was damaging the Australian industry reputation; the reduced mortality therefore may have increased export demand. • A potential increase in positive regional spill-over impacts from gains in incomes in regional businesses servicing the live SRL export industry. • Contribution to enhanced capacity and capability of Australian animal and fisheries scientists.

Pathway to Impact

A diagram describing the simplified pathways to impact for the investment in Project 2016-235 is provided in Figure 1.

Figure 1: Pathway to Impact for Project 2016-235



Nominal Investment

Table 2 shows the annual investment made in Project 2016-235 by FRDC, University of Tasmania, the Tasmanian Rock Lobster Processors Association (TRLPA) and the South Australian Rock Lobster Advisory Council (SARLAC).

Table 2: Annual Investment in Project 2016-235 (nominal $)

Year ended 30 June	FRDC ($)	University of Tasmania ($)	TRLPA and SARLAC ($)		TOTAL ($)
			Cash	In-kind	
2017	360,486	67,317	61,875	21,000	510,678
2018	180,243	95,566	60,875	29,000	365,684
2019	67,932	21,364	0	0	90,296
2020	55,158	0	0	0	55,158
Totals	664,189	184,247	122,750	50,000	1,021,816

Source: FRDC Project Agreement and FRDC Financial Acquittal

Program Management Costs

For the FRDC investment, the cost of managing the FRDC funding was added to the FRDC contribution for the project via a management cost multiplier (x1.179). This multiplier was estimated based on the share of 'employee benefits' and 'supplier' expenses in total FRDC expenditure reported in the FRDC's Cash Flow Statement (FRDC, 2017-2021). This multiplier then was applied to the nominal investment by FRDC shown in Table 2. A multiplier of 1.00 was applied to the nominal investment by the University of Tasmania, TRLPA and SARLAC.

Real Investment and Extension Costs

For purposes of the investment analysis, the investment costs of all parties were expressed in 2020/21-dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2021). No additional costs of extension were included as the outcomes and impacts were largely driven by project activities including communication carried out with the SRL industry within and after the project.

Impacts

Table 3 provides a summary of the principal types of impacts expanded from those listed in Table 1 and categorised into economic, environmental and social impacts.

Table 3: Triple Bottom Line Categories of Principal Impacts from Project 2016-235

Economic	• Reduction in the value of financial losses of live SRL exports affecting Australian SRL exporters and businesses associated with their supply chains. • Increased market resilience through improved product quality. • Increased costs of monitoring of water quality and stress conditions.
Environmental	• Nil
Social	• Enhanced capacity and capability of Australian animal scientists. • Positive impacts on regional communities influenced by the increased profitability of live SRL exports and their supply chains. • Spill-over impacts to regional communities associated with SRL supply chain businesses.

Public versus Private Impacts

The principal private impacts identified in this evaluation is directly related to minimising economic losses to the Australian SRL industry and increased market resilience through improved product quality. The public impacts include a potentially improved image of the Australian SRL industry, spill-over benefits to some communities servicing the SRL industry and their supply chains, and an increase in the capacity and capability of Australian scientists.

Distribution of Private Impacts

The benefits from reduced losses and any additional costs will directly accrue to SRL exporters in the first instance. Such private benefits likely will be shared by members of the various SRL supply chains according to associated supply and demand elasticities.

Impacts on Other Australian Industries

It is expected that there would be negligible impacts on other Australian primary industries.

Impacts Overseas

The major impact overseas will be an enhanced satisfaction of importing live SRL from Australia through improved product quality and higher rates of saleable product.

Match with National Priorities

Australian Agriculture, Science, and Research Priorities

The Australian Government's National Science and Research Priorities and Agricultural Innovation Priorities are reproduced in Table 4. Project 2016-235 contributed to National Science and Research Priority 1. Further, the RD&E investment is likely to contribute directly to Agricultural Innovation Priority 1 because of improved SRL product quality and enhanced international consumer satisfaction.

Table 4: Australian R&D Priorities

Australian Government	
National Science and Research Priorities[1]	**National Agricultural Innovation Priorities**[2]
1. Food – optimising food and fibre production and processing; agricultural productivity and supply chains within Australia and global markets. **2. Soil and Water** – improving the use of soils and water resources, both terrestrial and marine. **3. Transport** – boosting Australian transportation: securing capability and capacity to move essential commodities; alternative fuels; lowering emissions. **4. Cybersecurity** – improving cybersecurity for individuals, businesses, government, and national infrastructure. **5. Energy and Resources** – supporting the development of reliable, low cost, sustainable energy supplies and enhancing the long-term viability of Australia's resources industries. **6. Manufacturing** – supporting the development of high value and innovative manufacturing industries in Australia. **7. Environmental Change** – mitigating, managing, or adapting to changes in the environment. **8. Health** – improving the health outcomes for all Australians.	On 11 October 2021, the National Agricultural Innovation Policy Statement was released. It highlights four long-term priorities for Australia's agricultural innovation system to address by 2030. These priorities replace the Australian Government's Rural Research, Development and Extension Priorities which were published in the 2015 Agricultural Competitiveness White Paper. **1.** Australia is a trusted exporter of premium food and agricultural products by 2030. **2.** Australia will champion climate resilience to increase the productivity, profitability, and sustainability of the agricultural sector by 2030. **3.** Australia is a world leader in preventing and rapidly responding to significant incursions of pests and diseases through futureproofing our biosecurity system by 2030. **4.** Australia is a mature adopter, developer, and exporter of digital agriculture by 2030.

FRDC National RD&E Priorities

Through extensive consultation, the FRDC 2015-2020 RD&E Plan identified three national RD&E priorities to focus and direct FRDC investments. The three FRDC national RD&E priorities were:

1. Ensuring that Australian fishing and aquaculture products are sustainable and acknowledged to be so.
2. Improving productivity and profitability of fishing and aquaculture.
3. Developing new and emerging aquaculture growth opportunities.

Project 2016-235 directly addressed FRDC national RD&E priority 2 minimising economic losses to the Australian SRL industry and increased market resilience through improved product quality.

[1] Source: 2015 Australian Government *Science and Research Priorities*. https://www.industry.gov.au/data-and-publications/science-and-research-priorities.

[2] Source: 2021 National Agriculture Innovation Policy Statement. https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/research_and_development_corporations_and_companies#government-priorities-for-investment.

Valuation of Impacts

Impact Valued

A single impact was valued in the assessment of FRDC Project 2016-235. This impact is increased net profit for exporters of live SRL.

The valuation of this impact relies on the premise that the project investment has reduced the morbidity and death of some live exports of SRL. A wide range of project studies (e.g. biochemical, immunological, microbiological, pathological, and water quality testing) has contributed to an improved understanding of mainstream causes of lobster morbidity after the time SRL are caught and landed. This improved understanding, together with workshops with industry, has contributed to changes in management practices in turn resulting in lowered lobster mortality and increased net profits for some exporters, despite some increase in operating costs.

Specific assumptions made for the valuation of the impact are provided in Table 5. A number of the assumptions involved some uncertainty, so that a degree of conservatism was effected when finalising the assumptions for valuing the impact.

Impacts Not Valued

The social impacts identified in Table 3 were:

- The enhanced capacity and capability of Australian animal scientists.
- The positive impacts on regional communities.
- Spill-over impacts to regional communities associated with SRL supply chain businesses.

These social impacts were not valued as credible data and information was unavailable on which to base assumptions. However, to some degree, some of the capacity and capability impact was valued in the valuation of increased net profits for SRL exporters.

Summary of Assumptions

Table 5 (below) presents the specific assumptions used in the valuation of the impact.

Table 5: Summary of Assumptions

Variable	Assumption	Source
Average gross value of SRL product	$184 m per annum (3 year average)	SRL Strategy (2022)
Value of exported SRL	$175 million per annum	95% of $184m per annum (assumes 5% domestically consumed)
Proportion of value of industry exports lost after landing due to mortality before FRDC project 2016-235	7.5%	Analyst assumption
Proportion of value of exports lost after landing after industry response since FRDC project 2016-235	5.0%	
Additional costs of monitoring of water quality and stress conditions	25% of value of export value gain	
Time incidence of net impact	2021 to 2025	
Risk factors and counterfactual		
Probability of output	100%	Analyst assumption
Probability of outcomes occurring	75%	
Probability of impacts occurring given successful outcome	75%	
Counterfactual: Impacts assumed would have occurred five years later as industry would have carried out its own investigations and found improved management practices		

Results

All costs and benefits were expressed in 2020/21-dollar terms. All costs and benefits were discounted to 2021/22 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2019/20) to the final year of benefits assumed.

Investment Criteria

Tables 6 and 7 show the investment criteria estimated for different periods of benefits for the total investment and FRDC investment respectively. The FRDC benefits were estimated by multiplying the total present value of benefits (PVB) by the FRDC proportion of real undiscounted investment costs (68.6%).

Table 6: Investment Criteria for Total Investment in Project 2016-235

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.00	8.81	8.81	8.81	8.81	8.81	8.81
Present value of costs ($m)	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Net present value ($m)	-1.51	7.30	7.30	7.30	7.30	7.30	7.30
Benefit-cost ratio	0.00	5.83	5.83	5.83	5.83	5.83	5.83
Internal rate of return (%)	negative	49.1	49.1	49.1	49.1	49.1	49.1
MIRR (%)	n.s.	136.8	42.4	26.7	20.2	16.8	14.6

n.s.: no solution

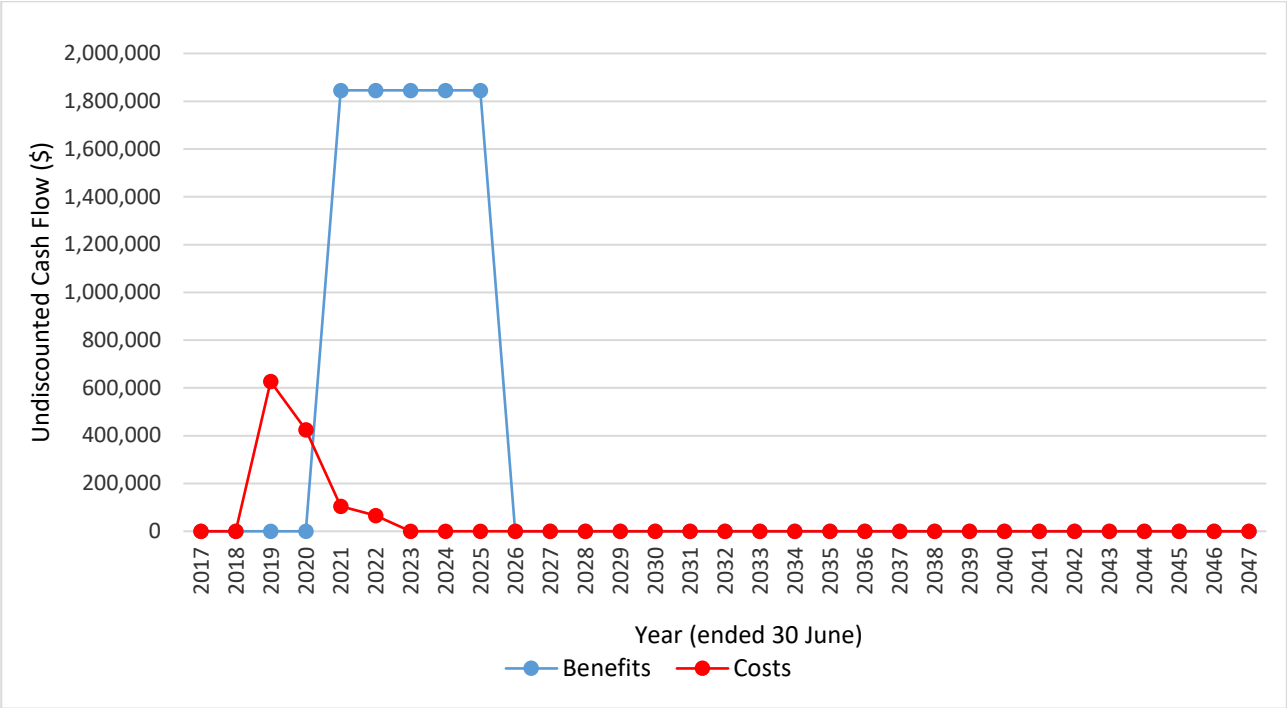
Table 7: Investment Criteria for FRDC Investment in Project 2016-235

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.00	6.04	6.04	6.04	6.04	6.04	6.04
Present value of costs ($m)	1.04	1.04	1.04	1.04	1.04	1.04	1.04
Net present value ($m)	-1.04	5.01	5.01	5.01	5.01	5.01	5.01
Benefit-cost ratio	0.00	5.83	5.83	5.83	5.83	5.83	5.83
Internal rate of return (%)	negative	49.1	49.1	49.1	49.1	49.1	49.1
MIRR (%)	n.s.	86.0	30.1	19.8	15.5	13.1	11.6

n.s.: no solution

The annual undiscounted benefit and cost cash flows for the total investment for the duration of investment period plus 30 years from the last year of investment are shown in Figure 2.

Figure 2: Annual Cash Flow of Undiscounted Total Benefits and Total Costs



Sensitivity Analyses

A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table 8 presents the results. The results showed a moderately low sensitivity to the discount rate, largely due to the short period of benefits valued and the benefit period commencing shortly after the project was completed.

Table 8: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	**Discount rate**		
	0%	**5% (base)**	**10%**
Present value of benefits ($m)	9.23	8.81	8.47
Present value of costs ($m)	1.22	1.51	1.85
Net present value ($m)	8.01	7.30	6.61
Benefit-cost ratio	7.55	5.83	4.57

A sensitivity analysis was undertaken also on the assumption of the proportion of value of exports lost after landing after the project. Results are shown in Table 9. For the project investment to break even, there would need to have been a loss of 7.5% before the project falling to 7.1 % after the project.

Table 9: Sensitivity to Assumption of Proportion of Value of Exports Lost After Industry Response
(Total investment, 30 years)

Investment Criteria	**Proportion of Value of Exports Lost after the Project**		
	4%	**5% (Base)**	**6%**
Present value of benefits ($m)	12.33	8.81	5.29
Present value of costs ($m)	1.51	1.51	1.51
Net present value ($m)	10.82	7.30	3.77
Benefit-cost ratio	8.16	5.83	3.50

Confidence Ratings and other Findings

The results produced are highly dependent on the assumptions made, some of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 10). The rating categories used are High, Medium and Low, where:

High:	denotes a good coverage of benefits or reasonable confidence in the assumptions made
Medium:	denotes only a reasonable coverage of benefits or some uncertainties in assumptions made
Low:	denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 10: Confidence in Analysis of Project

Coverage of Benefits	**Confidence in Assumptions**
Medium-High	Medium-Low

The coverage of benefits was assessed as Medium-High. While the important industry economic impacts were valued, the three social impacts identified were not valued For the impacts valued, many of the assumptions used were realistic but the critical assumptions of the proportion of exports lost before and after the project were necessarily subjective. Hence, an overall rating of confidence in the assumptions was considered Medium-Low.

Conclusions

The overall finding of the project investment was that the SRL industry has gained significantly by lowering the incidence of morbidity and death of many live exports of SRL.

Funding for the project over four years $1.51 million (present value terms). The single impact valued gave estimated benefits of $8.81 million (present value terms). This gave a net present value of $7.30 million, a benefit-cost ratio of 5.83 to 1, an internal rate of return of 49.1% and a modified internal rate of return of 14.6%.

The set of investment criteria estimated are uncertain due to the lack of specific industry evidence of the decrease in mortality. On the other hand, several other potential impacts were identified but not valued in monetary terms. This meant that the investment criteria as estimated in the evaluation are likely to be an underestimate of the total value of the project investment.

Glossary of Economic Terms

Cost-benefit analysis:	A conceptual framework for the economic evaluation of projects and programs in the public sector. It differs from a financial appraisal or evaluation in that it considers all gains (benefits) and losses (costs), regardless of to whom they accrue.
Benefit-cost ratio:	The ratio of the present value of investment benefits to the present value of investment costs.
Discounting:	The process of relating the costs and benefits of an investment to a base year using a stated discount rate.
Internal rate of return:	The discount rate at which an investment has a net present value of zero, i.e., where present value of benefits = present value of costs.
Investment criteria:	Measures of the economic worth of an investment such as Net Present Value, Benefit-Cost Ratio, and Internal Rate of Return.
Modified internal rate of return:	The internal rate of return of an investment that is modified so that the cash inflows from an investment are re-invested at the rate of the cost of capital (the re-investment rate).
Net present value:	The discounted value of the benefits of an investment less the discounted value of the costs, i.e. present value of benefits - present value of costs.
Present value of benefits:	The discounted value of benefits.
Present value of costs:	The discounted value of investment costs.

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