FINAL REPORT

An Impact Assessment of Investment in FRDC Project 2018-164:

Commercial production trial with high POMS tolerant triploid Pacific oysters in approved New South Wales estuaries

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An Impact Assessment of Investment in FRDC Project 2018-164: Commercial production trial with high POMS tolerant triploid Pacific oysters in approved New South Wales estuaries
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The Fisheries Research and Development Corporation plans, invests in and manages fisheries research and development throughout Australia. It is a statutory authority within the portfolio of the federal Minister for Agriculture, Fisheries and Forestry, jointly funded by the Australian Government and the fishing industry.

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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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Project leader Matthew Cunningham, General Manager, Australian Seafood Industries Pty Ltd was contacted to review the working draft.

Abbreviations

2n	Diploid
3n	Triploid
4n	Tetraploidy
ABS	Australian Bureau of Statistics
ASI	Australian Seafood Industries Pty Ltd
CBA	Cost-Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EBV	Estimated Breeding Value
FRDC	Fisheries Research and Development Corporation
MIRR	Modified Internal Rate of Return
NSW	New South Wales
NSW DPI	New South Wales Department of Primary Industries
OsHV-1	Ostreid Herpesvirus-1
POMS	Pacific Oyster Mortality Syndrome
PVB	Present Value of Benefits
RD&E	Research, Development, and Extension

Executive Summary

This report presents an impact assessment of investment in Fisheries Research and Development Corporation (FRDC) 2018-164: *Commercial production trial with high POMS tolerant triploid Pacific Oysters in approved NSW estuaries*. The assessment was completed as part of a cost-benefit analysis for inclusion in the FRDC 2022-23 Annual Report. The assessment was made up of six FRDC RD&E projects.

The impact assessment 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 impact assessment guidelines of the Council of Rural Research and Development Corporations.

FRDC Project 2018-164 was funded to support and investigate an innovative program where highly POMS resistant triploid Pacific oyster spat were produced directly via induction in Tasmania and then shipped utilising the export/import protocols in place between Tasmania and Hawkesbury River NSW for Hawkesbury River farmers to evaluate, under large scale protocols, and test the commercial viability of the new POMS resistant genetics.

Despite some challenges due to flooding during the project period, the investment produced useful knowledge and other outputs and has contributed to positive impacts, including:

- Increased rate of recovery of Pacific oyster production in affected regions. This impact is driven by increased producer awareness of and confidence in the availability of POMS resistant spat, improving interstate import/export processes for spat, and improved data on commercial performance of POMS resistant family lines in POMS affected areas to enhance breeding program outcomes.
- Increased knowledge and scientific capacity associated with the movement and commercial trial of disease resistant oyster spat.
- Improved community well-being through the regional spill-over benefits of the recovery and maintenance of the Australian Pacific oyster industry in POMS affected areas.

Total funding for the Project was $0.18 million (present value terms), with an FRDC contribution of $0.12 million (present value terms). The investment produced total expected net benefits of $0.39 million (present value terms). This gave an estimated net present value of $0.20 million, a benefit-cost ratio of 2.1 to 1, an internal rate of return (IRR) of 4.0%, and a modified IRR of 7.5% (over 30 years, using a 5% discount rate and 5% finance rate).

Given the conservative assumptions made, the fact that two impacts were not valued in monetary terms, and that sensitivity analyses showed that the results remained positive even when more pessimistic/ conservative assumptions were tested, the investment criteria reported are likely to be an underestimate of the true performance of the investment in Project 2018-164 and the positive results should be viewed favourable by FRDC, the Australian Government, industry, and other RD&E stakeholders.

Keywords

2018-164, Pacific oysters, triploid Pacific oyster, Pacific oyster Mortality Syndrome, POMS, POMS resistance, instant induction technique, evaluation, impact assessment, cost-benefit analysis

Introduction

The Fisheries Research and Development Corporation (FRDC) required a series of cost-benefit analyses of selected research, development, and extension (RD&E) investments (projects) for inclusion in the FRDC 2022/23 Annual Report. The assessments were completed to contribute to the following FRDC evaluation reporting requirements:

- Reporting against the FRDC 2020-2025 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 August 2023, FRDC commissioned ACRE Economics Pty Ltd and associates to undertake cost-benefit analyses (CBAs) of six RD&E projects funded under the FRDC 2020-2025 RD&E Plan and completed in the years ended 30 June 2017 to 2021. The projects were selected by FRDC and spanned the organisation's current RD&E Programs and Strategic Outcomes. The projects were selected by FRDC and spanned the organisation's current RD&E Programs and Strategic Outcomes. The sample selected (six projects) comprises a relatively small proportion of the FRDC's total RD&E investment (~5%) of the relevant population and may, therefore, not be fully representative of the entire RD&E Portfolio. However, the projects evaluated provide insight into the activities and outputs associated with each of FRDC's RD&E Programs, and the outcomes and impacts (and benefits) created. In turn, this will enable communication of benefits of FRDC RD&E to the FRDC Board, funding partners including the Commonwealth, industry, and other stakeholders.

The six projects selected by FRDC for evaluation in calendar 2023 were:

1. 2016-224: *Boosting fisher returns through smart value adding and greater use of underutilised species*
2. 2016-261: *Investigating the use of trace element profiles to substantiate provenance for the Australian prawn industry*
3. 2018-164: *Our Pledge: Australian seafood industry response to community values and expectations*
4. 2018-148: *A Stock Assessment Toolbox for Australian Fisheries*
5. 2018-164: *Commercial production trial with high POMS tolerant triploid Pacific Oysters in approved NSW estuaries*
6. 2018-205: *Informing strategies, policies and options supporting owner-operated fishing businesses in fisheries experiencing corporatisation*

This report presents the assessment process and findings for 2018-164: *Commercial production trial with high POMS tolerant triploid Pacific Oysters in approved NSW estuaries*.

Evaluation Framework

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 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 viral disease known as Pacific Oyster Mortality Syndrome (POMS), caused by infection with a microvariant genotype of ostreid herpesvirus-1 (OsHV-1), was first diagnosed in Australia in the Georges River in New South Wales (NSW) in 2011 and then in the Hawkesbury River in NSW in 2013 and Tasmania in February 2016. The disease had significant negative impacts on the Australian Pacific oyster industry, particularly in the Hawkesbury River where losses of up to 98% of oyster stock occurred and POMS losses were compounded by farmers' inability to access QX[1] resistant Sydney Rock Oysters for the next two seasons. Ongoing monitoring has confirmed that the POMS virus (and QX) persists in the wild stocks in the river systems.

The hatcheries that produce most of the Pacific oyster spat for Australia and that supply the Hawkesbury River triploid (3n) Pacific oysters are based in Tasmania. Since POMS was first diagnosed in Australia, Hawkesbury River growers have collaborated with Australian Seafood Industries Pty Ltd (ASI), leader of the Australian-wide Pacific oyster selective breeding program, and other research institutes (including NSW Department of Primary Industries (NSW DPI), Sydney University, Macquarie University) for the development and selection of POMS resistant Pacific oysters.

However, Hawkesbury River grower access to the high-level POMS resistance genetics was difficult because the research and Pacific oyster breeding program for NSW were based in Port Stephens (NSW) where POMS was not present. Importation of resistant parent lines into Port Stephens was not possible because of existing biosecurity import/export restrictions between NSW and Tasmania. Access to POMS resistant triploid pacific oysters was made even more challenging for NSW farmers due to the extensive timelines and complexities associated with producing suitable 4n (tetraploidy) and 2n (diploid) parent lines under prevailing spat import protocols to supply triploid spat to the Hawkesbury River. Thus, by 2018/19, triploid Pacific oysters incorporating the highly resistant parent lines had not been commercially evaluated anywhere in Australia.

Rationale for Project 2018-164

FRDC Project 2018-154 was funded to support and investigate an innovative program proposed by Hawkesbury River farmers utilising relatively new triploid induction technology available via Cameron's Nursery[2] in Tasmania. Cameron's was to produce highly resistant triploid Pacific oyster spat directly via induction and utilising the export/import protocols in place between Tasmania and Hawkesbury River NSW for Hawkesbury River farmers to evaluate, under large scale protocols, and test the commercial viability of the new POMS resistant genetics. Further, the project funding would enable Hawkesbury River growers to access, import, and fairly assess and record survival and performance data and to provide meaningful feedback to ASI on the ability of the selected POMS resistant family lines to withstand environmental infection of POMS under commercial growing conditions.

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[1] QX is a seasonally occurring disease of Sydney Rock Oysters (*Saccostreaglomerata*) that has impacted a number of estuaries in NSW. QX stands for "Queensland Unknown" and the term has been in use since the 1960s when mortalities were first observed in cultivated oysters in southeast Queensland prior to the cause being identified (NSW Department of Industry, n.d.(a)).

[2] Cameron of Tasmania is a hatchery and nursery that is a major producer and supplier of seed oysters to Tasmania and South Australia. For more information see: http://www.cameronsoysters.com/html/history.html

Project Details

Summary

Project Code: 2018-164
Title: *Commercial production trial with high POMS tolerant triploid Pacific Oysters in approved NSW estuaries*
Research Organisation: ASI
Principal Investigator: Matthew Cunningham, General Manager, ASI
Period of Funding: March 2019 to April 2020
FRDC Program Allocation: Industry (100%)

Objectives

The specific objectives of the project were to:

1. Determine if POMS resistant triploid ASI oysters can improve the commercial viability of POMS affected NSW oyster farms, especially the Hawkesbury River.
2. Develop with ASI/CSIRO a recording and reporting format to assess the performance of triploid POMS resistant ASI Pacific Oyster spat cultured in the Hawkesbury River under commercial growing conditions.
3. Data collected from farms will determine performance and survival of predicted high POMS resistant triploid ASI Pacific Oysters cultured in POMS affected NSW oyster farms.
4. Develop protocols to test/sample for OsHV-u1, that are incorporated into regular assessment processes, to ensure that results can be reflected against a known challenge to POMS.

Logical Framework

Table 1: Logical Framework for FRDC Project 2018-164

Activities	• A commercial production trial with high POMS tolerant triploid Pacific oysters in approved NSW estuaries was undertaken between April 2019 and July 2020. • Triploid Pacific oyster spat was successfully produced through direct induction techniques by Cameron of Tasmania at their bio-secure hatchery in Tasmania. • Highly resistant ASI family lines using YC15 families with estimated breeding values[3] (EBVs) for POMS resistance between 80% and 90% were used in the production of the triploid spat in January 2019. • The project team worked with the Tasmanian and NSW authorities to extend the existing NSW import protocol for oyster spat to allow Cameron of Tasmania to ship the trial batch to the Hawkesbury River growers. • The triploid spat then was subjected to, and passed, the biosecurity requirements for shipment to NSW.

[3] Estimated Breeding Values (EBVs) allow primary producers to evaluate an animal's genetic potential for a range of traits that directly impact on the profitability of the production enterprise. EBVs typically are calculated based on the lineage and performance data of a parental line's progeny and family in relation to a range of genetic traits.

	• Spat were received by ten participating growers from the Hawkesbury River estuary on the 17th or 18th of April 2019. Each grower received approximately 200,000 spats, divided over two size classes; 1.6 mm (~60,000 spat) and 2 mm (~140,000 spat). The number of spat allocated to each grower was estimated by weight. • The spat received by each participating grower were farmed on their own oyster farming leases and maintained at a commercial density and in units typically used by each grower to effectively capture a 'proof of product' test and assess the commercial viability of the spat. • A data reporting template was developed and provided to each grower to record the data that was required to understand individual farming practices, stock management and survivorship and growth of the triploid spat. • POMS activity was documented by growers throughout the trial.
Outputs	• Over the project trial period (April 2019 to April 2020), the first reported oyster mortality event occurred in late November 2019 with five percent mortality of 6mm stock held in intertidal baskets. No other mortality was noted until late December 2019. • A separate grower noted up to 30% mortality in 12 mm stock unrelated to the ASI trial. Tissue samples were collected but not immediately tested for OsHV-1 as the laboratory was closed for the Christmas period. • A third grower reported between 30% and 40% mortality of 6mm stock from the ASI trial that were held in floating baskets in early January 2020. Samples were collected and returned a negative result for OsHV-1. • On February 7th, 2020, the Hawkesbury River catchment received 340mm of rainfall over a four-day period. The Hawkesbury River and its estuaries were subjected to extensive flooding with freshwater. • Salinity levels were monitored by growers and were found to have decreased to zero at the mouth of the Hawkesbury River. Stock was submerged for excessive periods of time during the flood event. Further, the Hawkesbury River catchment received a further 230 mm of rainfall over the following two months which prolonged the effects of the flood event. The estuary was not reopened for commercial harvest and stock sales until May 1st, 2020. • According to normal practices, stock was not handled during or after the flood event for a period of time deemed suitable for recovery. Handling time-points varied between growers. Consequently, it was not possible for some growers to count the mortality of the triploid stock directly following the flood event. • A similar approach was taken by the growers not to handle their stock following the first POMS event. Most farmers hadn't worked their oysters after the mortality event in January 2020 or before the flood event. Thus, it was difficult to get figures on whether the mortality recorded in the data sheets was due to the POMS event or the flood event for that time period. • Growers had reported growth, including a volume explosion and excellent winter growth prior to both events (POMS and flooding). • A second POMS event was reported by a number of growers in late April 2020. • Growers received spat, unrelated to the ASI trial, in the first week of April. Growers recorded close to 100% mortality of the spat by the end of the month. • Tissue samples were collected and returned a positive result for OsHV-1 when tested by NSW DPI. • There were no reports of mortality in the ASI trial, though this may have been due to a reduction in the number of growers maintaining observations and reporting data. • The project team observed that that the Cameron of Tasmania trial stock (10 months old at the time of the second POMS event) showed high resistance for the second POMS event with very few losses compared to nearby younger stock (weeks old) from others exhibiting 90 percent mortality.

	• Although the trial was affected by an unforeseen and major flood event that impacted data collection, there was evidence of ASI spat survival following a POMS outbreak. • Growers recorded between 50% to 70% survival of spat following the first POMS event, which was predominantly restricted to smaller size classes. • Four growers continued to monitor their trial oysters in to 2020, following the second POMS event. These four growers recorded between 10% and 45% of the original allocation of spat had survived to at least April when stock was last checked. • Other growers did not continue to monitor stock following the flood event and consequently, had no record of mortality following the second POMS outbreak. The majority of these growers recorded major mortalities (in excess of 50%) following the flood event. • Some growers did not sample between the POMS and flood events which restricted the data available to the project. • Growers overall were happy with the survival of the spat given the disease and environmental stress events experienced during the trial. • Though the trial indicated potential for predicted high POMS resistant triploid ASI Pacific oysters in the Hawkesbury River estuary, it also highlighted the importance of farm management practices.
Outcomes	• Pacific oyster farmers in NSW have increased confidence that they will have a future growing triploid Pacific oyster with high POMS resistant spat that have demonstrated only 50% mortality (due to POMS). • Further, the trial increased NSW producer awareness of and confidence in the continued improvement each year in the family lines of high POMS resistant Pacific oyster spat available to them. • In conjunction with advances in QX resistance in Sydney Rock Oysters in the Hawkesbury region, in particular, the findings of Project 2018-164 increased confidence that the NSW industry can be reinvigorated in terms of oyster farming activity.
Impacts (Potential)	• Increased rate of recovery of Pacific oyster production in affected regions. This impact is driven by increased producer awareness of and confidence in the availability of POMS resistant spat, improving interstate import/export processes for spat, and improved data on commercial performance of POMS resistant family lines in POMS affected areas to enhance breeding program outcomes. • Increased knowledge and scientific capacity associated with the movement and commercial trial of disease resistant oyster spat. • Contribution to improved community well-being through the regional spill-over benefits of the recovery and maintenance of the Australian Pacific oyster industry in POMS affected areas.

Source: FRDC project documentation

Nominal Investment

Table 2 shows the total annual investment made in project 2018-164 by FRDC and other contributors. Other contributors included ASI and Cameron of Tasmania.

Table 2: Total Investment in FRDC Project 2018-164
(nominal dollar terms)

Year ended 30 June	FRDC ($)	Others ($)	Total ($)
2019	50,000	5,040	55,040
2020	20,000	45,000	65,000
Totals	**70,000**	**50,040**	**120,040**

Source: FRDC project 2018-164 documentation.

Management and Administration 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 a five-year average of the ratio of total FRDC cash expenditure to project expenditure reported in the FRDC's Cash Flow Statement (FRDC Annual Reports, 2018-2022). This multiplier then was applied to the nominal investment by FRDC shown in Table 2. A multiplier of 1.00 was used for administration and management costs for other contributors.

Real Investment and Extension Costs

For the purposes of the impact analysis, the investment costs of all parties were expressed in 2022/23-dollar terms using the Implicit Price Deflator for Gross Domestic Product (Australian Bureau of Statistics (ABS), 2023).

No additional costs of extension were included as the outputs and outcomes of Project 2018-164 were extended through regular updates to project participants who were ultimately the beneficiaries of the project.

Impacts

Table 3 provides a summary of the principal types of potential impacts from Project 2018-164. Impacts have been taken, and potentially expanded, from those listed in Table 1 and categorised using a triple bottom line framework into economic, environmental, and social impact types.

Table 3: Principal Potential Impact Types from Investment in FRDC Project 2018-164

Economic	• Increased rate of recovery of Pacific oyster production in affected regions. This impact is driven by increased producer awareness of and confidence in the availability of POMS resistant spat, improving interstate import/export processes for spat, and improved data on commercial performance of POMS resistant family lines in POMS affected areas to enhance breeding program outcomes.
Environmental	• Nil.
Social	• Increased knowledge and scientific capacity associated with the movement and commercial trial of disease resistant oyster spat. • Contribution to improved community well-being through the regional spill-over benefits of the recovery and maintenance of the Australian Pacific oyster industry in POMS affected areas.

Public versus Private Impacts

The impacts identified from Project 2018-164 were both private and public impacts. Private impacts will be delivered through improved productivity and profitability for the Australian Pacific oyster industry through increased rate of recovery for regions devastated by POMS.

Public impacts are expected to be achieved through increase knowledge and capacity and, potentially, spill over benefits to regional communities from the recovery and maintenance of the Pacific oyster industry.

Distribution of Private Impacts

In the short-term, private impacts from the investment in Project 2018-164 accrue to Pacific oyster farmers in POMS affected regions, particularly in NSW, and their direct supply chains. Over the longer term, private benefits will be distributed along Pacific oyster supply chains more broadly according to relevant supply and demand elasticities.

Impacts on Other Australian Industries

No direct impacts to other Australian industries beyond the Pacific oyster industry were identified. However, there may be knowledge spill overs or other synergies associated oyster breeding programs and movement and trial of advanced spat that could benefit other farmed oyster sectors, such as Syndey Rock Oysters, in the longer term.

Impacts Overseas

No direct impacts to overseas parties were identified.

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 2018-164 contributed to National Science and Research Priority 1. Further, the RD&E investment contributes indirectly to Agricultural Innovation Priorities 1 and 3.

Table 4: Australian R&D Priorities

Australian Government	
National Science and Research Priorities[4]	**National Agricultural Innovation Priorities**[5]
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.

[4] Source: 2015 Australian Government *Science and Research Priorities*. https://www.industry.gov.au/data-and-publications/science-and-research-priorities.
[5] 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.

FRDC National RD&E Priorities

Through extensive consultation, the FRDC 2020-2025 RD&E Plan identified five key outcome areas. The five outcome areas were:

1. Growth for enduring prosperity.
2. Best practices and production systems.
3. A culture that is inclusive and forward thinking.
4. Fair and secure access to aquatic resources.
5. Community trust, respect, and value.

Project 2018-164 addressed outcome areas 1 and 2, with some contribution to outcome 4.

Valuation of Impacts

The valuation of impacts generally focused on the most important and direct impacts of the investment in project 2018-164. The decision to value any of the impacts identified in Table 3 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.

Impacts Valued

One impact was valued for the assessment of Project 2018-164. The impact valued was:

- The investment's contribution to an increased rate of recovery of Pacific oyster production in POMS affected regions.

Valuation of Impact 1: Increased rate of recovery of oyster production

In NSW, POMS has been confirmed in three Pacific oyster producing estuary systems, Botany Bay/Georges River, Hawkesbury River, and Brisbane Water. POMS also has been confirmed in wild Pacific oysters in Sydney Harbour/Paramatta River, where oyster farming does not occur (NSW Department of Industry , n.d.(b)).

The valuation of an increased rate of recovery for Pacific oyster production focused on production in the Hawkesbury River and was underpinned by the current and expected future production of Pacific oysters taking into account Project 2018-164 contribution to increased producer awareness of and confidence in the availability of POMS resistant spat, improving interstate import/export processes for spat, and improved data on commercial performance of POMS resistant family lines in POMS affected areas to enhance breeding program outcomes.

Figure 1 shows the historical trend in Pacific oyster production for the Hawkesbury River from 2010 to 2022. Specific assumptions for valuing the impact are provided in Table 5.

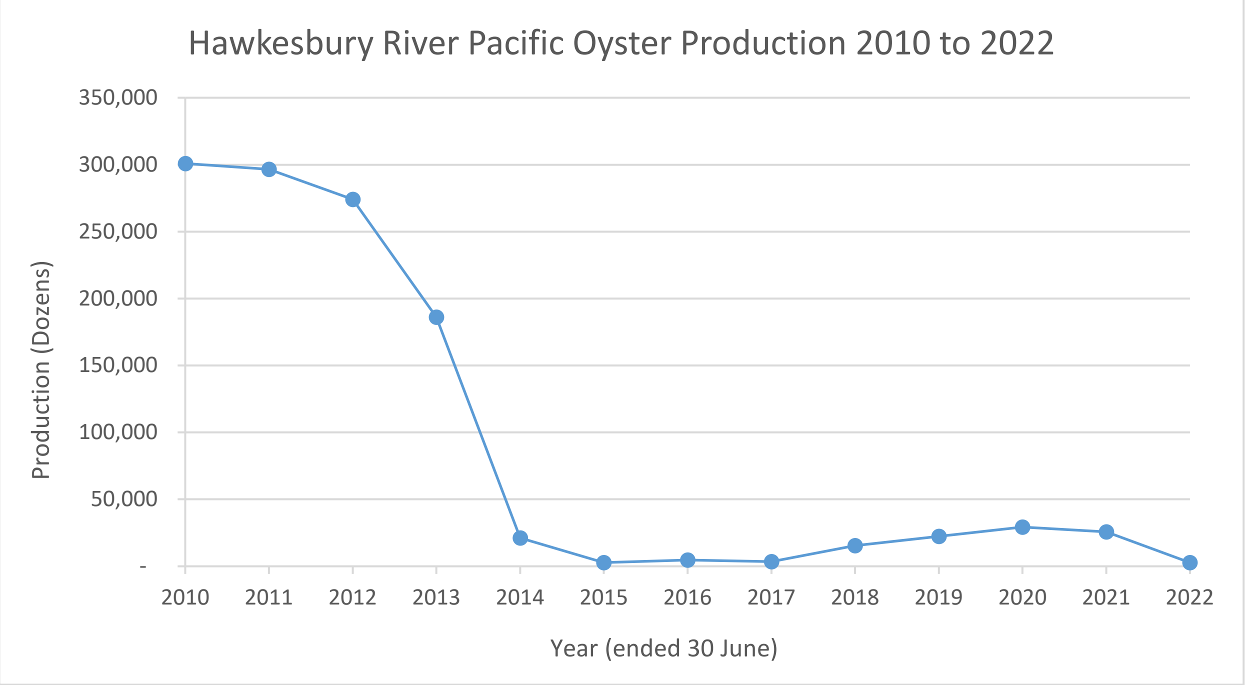

Figure 1:Hawkesbury River Pacific Oyster Production Over Time (2010 to 2022)
Source: Derived from NSW aquaculture production data 2010-2022 (NSW Department of Industry, n.d.(c))

Impacts Not Valued

The impacts not valued included:

- Increased knowledge and scientific capacity associated with the movement and commercial trial of disease resistant oyster spat.
- Contribution to improved community well-being through the regional spill-over benefits of the recovery and maintenance of the Australian Pacific oyster industry in POMS affected areas.

Summary of Assumptions

The following tables present the specific assumptions used in the valuation of Impact 1.

Table 5: Summary of Assumptions for the Valuation of Impact 1

Variable	Assumption	Source
BASELINE DATA (STATUS QUO – WITHOUT PROJECT 2018-164)		
Historic Pacific oyster production for the Hawkesbury River by year (dozens)		
2010	300,875	NSW DPI, Aquaculture Production Reports 2009-10 to 2021-22 (see Figure 1)
2011	296,620	
2012	274,181	
2013	186,093	
2014	21,221	
2015	2,855	
2016	4,745	
2017	3,373	
2018	15,492	
2019	22,264	
2020	29,390	
2021	25,665	
2022	2,745	
Production recovery trend equation (rate of recovery)	y = 2245.9x + 3209.7 where x = 1 for 2014/15 y = production (dozens) Rate of recovery = 2,246 dozen per annum	Based on recovering production trend in the Hawkesbury over the period 2015 to 2022 (see Figure 1) following peak losses after POMS was first diagnosed in NSW (2011/12 to 2013/14).
Average farm-gate price of Hawkesbury Pacific oysters	$13.00 per dozen	NSW DPI, Aquaculture Production Report 2022, average price of small and medium Pacific Oysters from Hawkesbury River (constituting approximatley 95% of sales)
WITH PROJECT 2018-164		
First year of impact	2021/22	Year after the last year of investment in project 2018-164 and publication of project report and findings.
Increased rate of recovery from project outputs and outcomes	1.5x the base rate of recovery (3,369 dozen per annum production increase)	Analyst assumption – 1.5 x est. base production recovery trend of 2,246 dozen per annum (see sensitivity analyses for further investigation).

Variable	Assumption	Source
Maximum level of production recovery for Hawkesbury Pacific oyster industry (production ceiling given presence of POMS)	80% of average, pre-POMS outbreak production	Analyst assumption - based on a 80% resistance target for new diploid varieties of Pacific oysters through the ASI breeding program (ASI, 2023)
Maximum potential future production for Hawkesbury River	172,638 dozen	80% x 215,798 dozen (2010 to 2014 average Hawkesbury River Pacific oyster production – prior to POMS diagnosis in NSW)
Other Economic Factors		
Attribution of benefits to specific investment in Project 2018-164	There have been multiple investments associated with POMS and aiding the recovery and economic sustainability of the NSW and broader Pacific oyster industry. Thus, given the specific assumptions used to value Impact 1, it was assumed that **20%** of the estimated benefits were directly attributable to the investment in Project 2018-164.	
Counterfactual – without investment in Project 2018-164	Due to the size of the Australian Pacific oyster industry and nature of funding for Pacific oyster RD&E, it was assumed that, without the investment in FRDC Project 2018-164, the estimated total expected net benefits would **not** have occurred.	
Probability of output.	100%	Based on completion of Project 2018-164 and the creation of useful RD&E outputs.
Probability of outcome.	90%	Refers to the likelihood that outputs of the project are adopted/used as estimated. Based on active producer engagement in Project 2018-164 and evidence of superior performance of POMS resistant spat in commercial settings in the Hawkesbury River.
Probability of impact.	90%	Allows for exogenous factors that may affect the realisation impacts as estimated (e.g., climate change, extreme weather events, other biosecurity incursions, etc.).

Results

All past costs and benefits were expressed in 2022/23-dollar terms. All costs and benefits were discounted to 2022/23 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 present value of benefits (PVB) for the FRDC investment was estimated by multiplying the total PVB cash flow by the proportion of FRDC investment in real, undiscounted dollar terms (62.5%).

Table 6: Investment Criteria for Total Investment in Project 2018-164

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.00	0.01	0.05	0.12	0.21	0.30	0.39
Present value of costs ($m)	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Net present value ($m)	-0.18	-0.18	-0.13	-0.06	0.02	0.11	0.20
Benefit-cost ratio	0.00	0.04	0.28	0.67	1.13	1.61	2.08
Internal rate of return (%)	negative	negative	negative	negative	0.87	2.92	4.00
MIRR (%)	negative	negative	negative	2.42	5.62	6.94	7.51

Table 7: Investment Criteria for FRDC Investment in Project 2018-164

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.00	0.00	0.03	0.08	0.13	0.19	0.24
Present value of costs ($m)	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Net present value ($m)	-0.12	-0.11	-0.08	-0.04	0.01	0.07	0.12
Benefit-cost ratio	0.00	0.03	0.28	0.66	1.12	1.59	2.06
Internal rate of return (%)	negative	negative	negative	negative	0.77	2.81	3.89
MIRR (%)	negative	negative	negative	2.34	5.56	6.90	7.48

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.

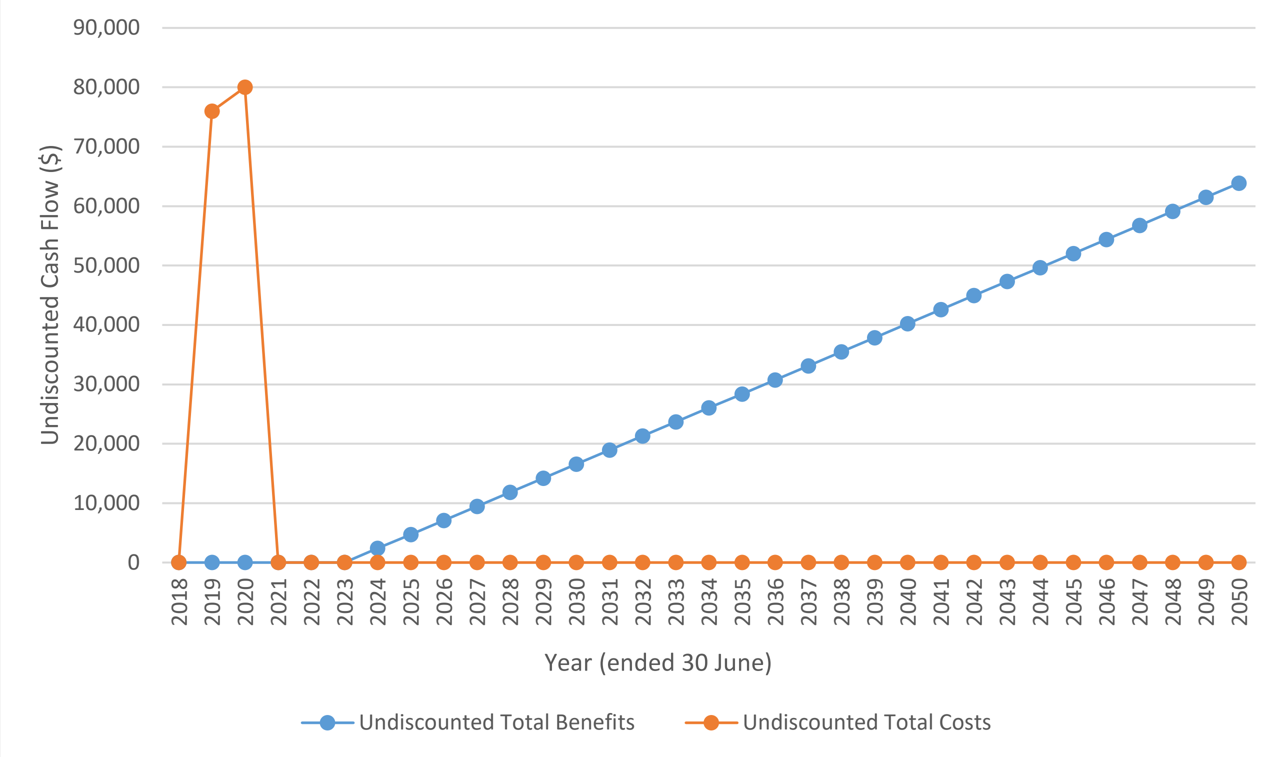

Figure 2: Annual Cash Flow of Undiscounted Total Benefits and Total Costs

Sensitivity Analyses

Sensitivity analyses were performed for variable that were considered (a) key drivers of the investment criteria, and/or (b) uncertain. Each sensitivity 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.

A sensitivity analysis was carried out on the discount rate. The results, shown in Table 8, showed a moderate to high sensitivity to the discount rate. This was largely due to the benefit cash flows occurring into the future and therefore being subject to relatively more severe discounting.

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

Investment Criteria	Discount rate		
	0%	**5% (base)**	**10%**
Present value of benefits ($m)	0.89	0.39	0.19
Present value of costs ($m)	0.16	0.18	0.22
Net present value ($m)	0.74	0.20	-0.03
Benefit-cost ratio	5.73	2.08	0.88

A sensitivity analysis then was carried out on the increase in the rate of recover for Pacific oyster production in the Hawkesbury River as this was uncertain and a key driver of the investment criteria. Table 9 shows the results. The investment criteria showed a moderate sensitivity to the assumed increase to the rate of recovery for Pacific oyster production. A break-even analysis indicated that the assumed increase in the rate of recovery (base of x1.5) could decline to x1.24 and the investment criteria would remain positive (benefit-cost ratio of at least 1 to 1) with all other assumptions held at their base values.

Table 9: Sensitivity to the Increase in the Rate of Recover for Pacific Oyster Production
(Total investment, 5% discount rate, 30 years)

Investment Criteria	**Increase in the Rate of Recover for Pacific Oyster Production**		
	1.2x	**1.5x (base)**	**1.8x**
Present value of benefits ($m)	0.15	0.39	0.62
Present value of costs ($m)	0.18	0.18	0.18
Net present value ($m)	-0.03	0.20	0.43
Benefit-cost ratio	0.83	2.08	3.33

Confidence Rating 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 Investment

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

The coverage of benefits was assessed as Medium to High. One of three impacts was valued and the impact valued was considered the most direct and important benefit of the investment in Project 2018-164.

Confidence in assumptions was rated as Medium. Much of the data and assumptions used in the CBA were developed using credible, published sources and expert opinion. However, as the project ended in 2019/20 there was scarce evidence/data on actual outcomes and impacts. Despite some uncertainty, sensitivity analyses showed that, even at more conservative values, the investment criteria were positive.

Conclusions

FRDC Project 2018-164 was funded to support and investigate an innovative program where highly POMS resistant triploid Pacific oyster spat were produced directly via induction in Tasmania and then shipped utilising the export/import protocols in place between Tasmania and Hawkesbury River NSW for Hawkesbury River farmers to evaluate, under large scale protocols, and test the commercial viability of the new POMS resistant genetics.

Despite some challenges due to flooding during the project period, the investment produced useful knowledge and other outputs and has contributed to positive impacts, including:

- Increased rate of recovery of Pacific oyster production in affected regions. This impact is driven by increased producer awareness of and confidence in the availability of POMS resistant spat, improving interstate import/export processes for spat, and improved data on commercial performance of POMS resistant family lines in POMS affected areas to enhance breeding program outcomes.
- Increased knowledge and scientific capacity associated with the movement and commercial trial of disease resistant oyster spat.
- Improved community well-being through the regional spill-over benefits of the recovery and maintenance of the Australian Pacific oyster industry in POMS affected areas.

Total funding for the Project was $0.18 million (present value terms), with an FRDC contribution of $0.12 million (present value terms). The investment produced total expected net benefits of $0.39 million (present value terms). This gave an estimated net present value of $0.20 million, a benefit-cost ratio of 2.1 to 1, an internal rate of return (IRR) of 4.0%, and a modified IRR of 7.5% (over 30 years, using a 5% discount rate and 5% finance rate).

Given the conservative assumptions made, the fact that two impacts were not valued in monetary terms, and that sensitivity analyses showed that the results remained positive even when more pessimistic/ conservative assumptions were tested, the investment criteria reported are likely to be an underestimate of the true performance of the investment in Project 2018-164 and the positive results should be viewed favourable by FRDC, the Australian Government, industry, and other RD&E stakeholders.

Glossary of Economics 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.

References

Agtrans Research. (2019). *Cross-RDC Impact Assessment 2019.* Canberra ACT: Council of Rural Research and Development Corporations. Retrieved from http://www.ruralrdc.com.au/impact-assessment-and-performance/

Agtrans Research; AgEconPlus; and EconSearch. (2016). *Cross-RDC Impact Assessment and Performance Reporting Update.* Canberra ACT: Council of Rural Research and Development Corporations. Retrieved from http://www.ruralrdc.com.au/impact-assessment-and-performance/

Australian Bureau of Agricultural and Resource Economics and Sciences. (2022, March 10). *Research topics - Fisheries - Fisheries data.* Retrieved from Australian Government Department of Agriculture, Fisheries and Forestry ABARES: https://www.agriculture.gov.au/abares/research-topics/fisheries/fisheries-data#australian-fisheries-and-aquaculture-statistics-2020

Australian Government. (2015, May). Science and Research Priorities. *Science*. Department of Industry, Science, Energy and Resources. Retrieved from https://www.industry.gov.au/data-and-publications/science-and-research-priorities

Australian Seafood Industries Pty Ltd. (2023). *Our Breeding Program*. Retrieved from ASI Australian Seafood Industries : https://www.asioysters.com.au/our-breeding-program#:~:text=ASI's%20current%20research%20target%20is,to%20all%20Australian%20Oyster%20farmers.

Council of Rural Research and Development Corporations. (2018). *Cross-RDC Impact Assessment Program: Guidelines.* Canberra ACT: Council of Rural Research and Development Corporations. Retrieved January 2022, from http://www.ruralrdc.com.au/wp-content/uploads/2018/08/201804_RDC-IA-Guidelines-V.2.pdf

Department of Agriculture, Water and the Environment. (2019, November 4). *Rural Research, Development and Extension Priorities*. Retrieved from Australian Government - Department of Agriculture, Water and the Environment: https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/priorities

Fisheries Research and Development Corporation. (2017). *Annual Report 2016-17.* Canberra ACT: Fisheries Research and Development Corporation. Retrieved from https://www.frdc.com.au/annual-reports

Fisheries Research and Development Corporation. (2018). *Annual Report 2017-18.* Canberra ACT: Fisheries Research and Development Corporation. Retrieved from https://www.frdc.com.au/annual-reports

Fisheries Research and Development Corporation. (2019). *Annual Report 2018-19.* Canberra ACT: Fisheries Research and Development Corporation. Retrieved from https://www.frdc.com.au/annual-reports

Fisheries Research and Development Corporation. (2020). *Annual Report 2019-20.* Canberra ACT: Fisheries Research and Development Corporation. Retrieved from https://www.frdc.com.au/annual-reports

Fisheries Research and Development Corporation. (2021). *Annual Report 2020-21.* Canberra ACT: Fisheries Research and Development Corporation. Retrieved from https://www.frdc.com.au/annual-reports

NSW Department of Industry . (n.d.(b)). *Home > Fishing > Aquatic biosecurity > Resilient Aquaculture > Disease management in aquaculture > Oyster health and disease > Pacific Oyster Mortality Syndrome*. Retrieved from NSW Government Department of Primary Industries: https://www.dpi.nsw.gov.au/fishing/aquatic-biosecurity/aquaculture/aquaculture/oyster-health-and-disease/poms#:~:text=In%20NSW%2C%20POMS%20has%20been,oyster%20farming%20does%20not%20occur.

NSW Department of Industry. (n.d.(a)). *Home > Fishing > Aquatic biosecurity > Resilient Aquaculture > Disease management in aquaculture > Oyster health and disease > QX Disease*. Retrieved from NSW Government Department of Primary Industries: https://www.dpi.nsw.gov.au/fishing/aquatic-biosecurity/aquaculture/aquaculture/oyster-health-and-disease/qx-oyster-disease#:~:text=QX%20stands%20for%20Queensland%20Unknown,was%20first%20identified%20in%201976.

NSW Department of Industry. (n.d.(c)). *Home > Fishing > Aquaculture > Publications / extension > Aquaculture production reports.* Retrieved from NSW Government Department of Primary Industries: https://www.dpi.nsw.gov.au/fishing/aquaculture/publications/aquaculture-production-reports