FINAL

An Impact Assessment of FRDC Investment in 2015-232: Australian Seafood Industries Pacific Oyster Mortality Syndrome (POMS) investigation into the 2016 disease outbreak in Tasmania – ASI emergency response

Agtrans Research

August 2018

FRDC Project No **2016-134**

An Impact Assessment of FRDC Investment in 2015-232: Australian Seafood Industries Pacific Oyster Mortality Syndrome (POMS) investigation into the 2016 disease outbreak in Tasmania – ASI emergency response
Project 2016-134

2018

This publication (and any information sourced from it) should be attributed to **Hardaker, T., Chudleigh, P. & Abell, J., Agtrans Research, 2018, *An Impact Assessment of FRDC Investment in 2015-232: Australian Seafood Industries Pacific Oyster Mortality Syndrome (POMS) investigation into the 2016 disease outbreak in Tasmania – ASI emergency response*, November 2018. CC BY 3.0**

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.

Researcher Contact Details
Name: Talia Hardaker
Address: Suite 36, Benson House, Toowong QLD 4066
Phone: 07 3870 4047
Fax: 07 3371 3381
Email: talia@agtrans.com.au

FRDC Contact Details
Address: 25 Geils Court, Deakin ACT 2600
Phone: 02 6285 0400
Fax: 02 6285 0499
Email: frdc@frdc.com.au
Web: www.frdc.com.au

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

Contents

List of Tables

List of Figures

Acknowledgments

Agtrans Research and Consulting would like to thank Patrick Hone (Executive Director) and Nicole Stubing (Project Manager) of the Fisheries Research and Development Corporation for facilitating contact with relevant project personnel and for their guidance and feedback throughout the Impact Assessment process.

Matthew Cunningham, General Manager, Australian Seafood Industries Pty Ltd
Wayne Hutchinson, Research Portfolio Manager, Fisheries Research and Development Corporation

Abbreviations

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
ASI	Australian Seafood Industries
CRC	Cooperative Research Centre
CRRDC	Council of Rural Research and Development Corporations
EBV	Estimated Breeding Value
FRDC	Fisheries Research and Development Corporation
IMAS	Institute for Marine and Antarctic Studies
MIRR	Modified Internal Rate of Return
NSW DPI	New South Wales Department of Primary Industries
POMS	Pacific Oyster Mortality Syndrome
RD&E	Research, Development & Extension
UV	Ultra-Violet

Executive Summary

What the report is about

This report presents the results of an impact assessment of a Fisheries Research and Development Corporation (FRDC) investment in the *Australian Seafood Industries Pacific Oyster Mortality Syndrome (POMS) investigation into the 2016 disease outbreak in Tasmania – ASI emergency response*. The project was funded by FRDC over the period April 2016 to June 2016.

Methodology

The investment was analysed qualitatively within a logical framework that included activities and outputs, outcomes and impacts. Impacts were categorised into a triple bottom line framework. Principal impacts identified were then considered for valuation. Past and future cash flows were expressed in 2017/18 dollar terms and were discounted to the year 2017/18 using a discount rate of 5% to estimate the investment criteria.

Results/key findings

The major potential impact identified was of a financial nature and involved contribution to an earlier potential recover of Pacific Oyster production for POMS affected regions in Australia. The investment enabled the assessment, recovery and protection of key, POMS resistant family lines for the ASI Pacific Oyster breeding program and facilitated the continued provision of POMS free, and increasingly resistant, spat to Australian Pacific Oyster producers in the wake of the Tasmanian POMS outbreak.

Investment Criteria

Total funding for the project was $0.06 million (present value terms) and FRDC provided 100% of the investment. The project produced estimated total expected benefits of $0.60 million (present value terms). This gave a net present value of $0.53 million, an estimated benefit-cost ratio of 9.3 to 1, an internal rate of return of 115.4% and a modified internal rate of return of 13.1%.

Conclusions

The relatively small total investment in this project has demonstrated the significant potential impact of coordinated and timely responses to disease outbreaks for Australian aquaculture industries.

While a number of economic and social impacts identified were not valued, the linkages between the project and these impacts were weak and their impacts were considered uncertain and minor compared with the impacts valued. Nevertheless, combined with conservative assumptions for the impacts valued, investment criteria as provided by the valued impacts may be underestimates of the investment performance.

Keywords

Impact assessment, cost-benefit analysis, Pacific Oyster, Pacific Oyster Mortality Syndrome, POMS, Tasmania, ASI, POMS outbreak

Introduction

The Fisheries Research and Development Corporation (FRDC) required a series of impact assessments to be carried out annually on a number of investments in 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 stakeholders.
- Reporting to the Council of Rural Research and Development Corporations (CRRDC).

The first series of impact assessments, that included 20 randomly selected FRDC investments, was completed in August of 2017. The published reports for the first series of evaluations can be found at: http://frdc.com.au/Research/Benefits-of-research/2017-Portfolio-Assessment

The second series of impact assessments also included 20 randomly selected FRDC investments. The investments were worth a total of approximately $5.62 million (nominal FRDC investment) and were selected from an overall population of 96 FRDC investments worth an estimated $21.32 million (nominal FRDC investment) where a final deliverable had been submitted in the 2016/17 financial year.

The 20 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 26% 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.

Project 2015-232: *Australian Seafood Industries Pacific Oyster Mortality Syndrome (POMS) investigation into the 2016 disease outbreak in Tasmania – ASI emergency response* was selected as one of the 20 investments and was analysed in this report.

General Method

The impact assessments followed general evaluation guidelines that are now well entrenched within the Australian primary industry research sector including Research and Development Corporations, Cooperative Research Centres (CRCs), State Departments of Agriculture, and some Universities. The approach includes both qualitative and quantitative descriptions that are in accord with the impact assessment guidelines of the CRRDC (CRRDC, 2014).

The evaluation process involved identifying and briefly describing project objectives, activities and outputs, outcomes, and impacts. The principal economic, environmental and social impacts were then summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. Where impact valuation was exercised, the impact assessment uses cost-benefit analysis as its principal tool. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, a high degree of uncertainty surrounding the potential impact, or the likely low relative significance of the impact compared to those that were valued. The impacts valued are therefore deemed to represent the principal benefits delivered by the project. However, as not all impacts were valued, the investment criteria reported for individual investments potentially represent an underestimate of the performance of that investment.

Background and Rationale

Background

Pacific Oyster Mortality Syndrome

Pacific Oyster Mortality Syndrome (POMS) is a devastating disease affecting Pacific Oysters. It is caused by the virus *ostreid herpesvirus-1 microvariant* (OsHV-1 μVar). Oyster mortality resulting from the disease can be very high and occurs extremely rapidly (e.g. up to 100% mortality within days of initial detection). Studies in Europe found that POMS was detectable in oysters after mortalities ceased, which indicated that surviving oysters could act as carriers of the virus. All ages of Pacific Oysters may be affected, but spat and juvenile oysters often suffer higher mortalities (NSW DPI, n.d.).

The first POMS event in Australia occurred in late 2010, when high mortalities occurred in two estuaries in NSW (Botany Bay and Port Jackson). Nearly all of the cultivated Pacific Oysters in the Georges River (Botany Bay) died during that event.

The POMS Outbreak in Tasmania

The POMS virus was first detected in Tasmania in late January 2016. However, tests on stored frozen oysters indicated that the virus has been present in the State since at least mid-December 2015.

Since the detection of POMS in January 2016, Biosecurity Tasmania and the Tasmanian oyster industry have worked together to manage the effects of POMS on the Tasmanian industry. While the disease is a major concern for oyster producers, healthy oysters can still be harvested, and oyster products sold through retail outlets remain safe for human consumption.

The initial response to the detection of POMS in Tasmania included restrictions on the movement of oysters onto, and between, oyster farms. During the movement ban a structured testing program was undertaken to determine where the virus was present in the State.

Based on the information from the POMS testing program three areas of differing disease risk were identified as a basis for issuing movement permits (Biosecurity Tasmania, 2018). These areas were:

1. POMS free areas across the north of Tasmania;
2. Intermediate risk areas where there was little or no evidence of disease, but a risk of introduction of the disease; and
3. An infected area where POMS was known to occur.

Australian Seafood Industries Pty Ltd

Australian Seafood Industries (ASI), is an industry owned company that was formed in 2000. The company was created to continue the Australia-wide Pacific Oyster selective breeding program that originally commenced in 1997. The company's mission is to collaboratively advance the Australian oyster industry through selective breeding of oysters for POMS disease resistance.

ASI's breeding program targets five traits determined as economically important for the production of commercial oysters (ASI, 2015a). These traits are:

1. growth rate,
2. shell width index,
3. time to reach market condition,
4. mortality and uniformity,
5. POMS disease resistance.

Currently ASI is in its sixth generation of POMS selective breeding. Some of the elite performing lines (one-year old animals) have shown levels of resistance of up to 90 per cent. However, the mortality rates of young (2 to 3 month) spat are still much higher than those for one year old stock. ASI's current research target is to have a POMS resistant Pacific Oyster spat with average survival of greater than 80 per cent (for diploids at 2 to 3 months) to a POMS outbreak available to all Australian oyster farmers by 2019 (ASI, 2015b).

Rationale

ASI is solely responsible for the breeding of POMS resistant oysters. ASI’s only source of income is a voluntary levy on oyster spat sales, thus, funding for oyster breeding was extremely sensitive to oyster disease outbreaks and was severely impacted by the outbreak of POMS in Australia.

Project 2015-232 was funded to allow the emergency response undertaken by ASI in response to the POMS outbreak in Tasmania in January 2016.

Project Details

Summary

Project Code: 2015-232
Title: *Australian Seafood Industries Pacific Oyster Mortality Syndrome (POMS) investigation into the 2016 disease outbreak in Tasmania – ASI emergency response*
Research Organisation: Australian Seafood Industries Pty Ltd
Principal Investigator: Matthew Cunningham
Period of Funding: April 2016 to June 2016
FRDC Program Allocation: Industry (100%)

Objectives

The project's key objectives were:

1. Rescue of the latest generation of all ASI family lines by transferring selectively bred spat produced in December / January from Shellfish Culture Ltd to a quarantine facility at the Institute for Marine and Antarctic Studies (IMAS).
2. Assessment of the survival rate of brood stock of all ASI oyster family lines located in areas exposed to the POMS virus.
3. Multiplication of the best family lines with the highest survival rate as soon as possible to enable hatcheries to provide spat for a Progressive Industry Recovery Program.

Logical Framework

Table 1 provides a detailed description of the project in a logical framework.

Table 1: Logical Framework for Project 2015-232

Activities and Outputs	**Rescuing the latest generation of all ASI family lines** • The most recent generations of ASI oyster family lines were located at the land-based nursery facilities of Shellfish Culture Ltd. • The stock was deemed to be at high risk of exposure to POMS after the disease was detected in Tasmania in early 2016. There also was a risk that Shellfish Culture may have needed to disinfect their site which would have involved cutting off the water supply. • Given that a complete stock standstill had been put in place by the Tasmanian Chief Veterinary Officer, a three-stage methodology was developed. 1. Testing was undertaken to establish if spat had been exposed to the POMS virus. Spat were tested by Polymerase Chain Reaction at the Animal Health Laboratory, Department of Primary Industries, Parks, Water and Environment Tasmania. All spat tested negative for the POMS virus. 2. A water treatment system and quarantine measures were put in place to ensure that stock was protected from being infected. A water filtration system was developed for the spat and commissioned on the 3rd of February 2016 (two days after POMS was officially confirmed in Tasmania). An ultra-violet (UV) filtration unit also was used, and the oyster nursery was converted to a partial recirculation system to minimise water usage and maximise spat exposure time in the UV unit.

	3. A quarantine area was established at IMAS at Taroona (Tasmania) to guard against the possibility of a facility shutdown at Shellfish Culture. Clean (POMS free) spat were transferred, under permit, to the facility on the 2nd March 2015. • POMS negative family lines were returned to Pipeclay Lagoon (POMS affected) in May 2016 after the POMS season was finished. These families were to be challenged against POMS during the 2017 POMS season when oysters are approximately 12 months old. **Assessment of the survival rate of broodstock exposed to the POMS virus** • Mortality assessments were conducted in Pipeclay Lagoon, Pittwater, and Little Swanport. The three areas were chosen because they were POMS affected areas where ASI had family lines present. • Assessments were conducted from 17th February to 9th March 2016. • Data were collected on all year classes of ASI family lines. The data then were used to generate estimated breeding values (EBVs) for the trait of POMS resistance for all ASI family lines. • Results of the mortality assessments varied widely. EBVs ranged from 3.6% to 85.4% resistance to POMS. • Data also enabled researchers to calculate the increased rate of genetic gains made possible from breeding animals that survived POMS. • A broodstock inventory was developed for key commercial candidate families. **Multiplication of family lines with the highest survival rate** • The EBVs developed allowed identification of the most resistant ASI family lines. • Resistance information was used as the basis for allocation of broodstock to commercial hatcheries to allow partially resistant lines to be produced and distributed to industry as soon as possible. • Broodstock allocation began on the 11th April 2016. • A breeding calculator tool was developed.
Outcomes	• Supply of partially resistant broodstock lines now has resulted in commercial production of oysters from Australian farms. • The rescue and continued POMS free status of ASI broodstock has ensured an ongoing supply of commercial and breeding program oyster stock with increasing levels of POMS resistance. • The breeding calculator allowed commercial hatcheries to predict survival and inbreeding for potential commercial crosses of the most resistant families. • Further POMS RD&E now is being undertaken through the Future Oysters CRC Project (comprised of six sub-projects) that commenced in 2016.
Impacts	• Potential contribution to an earlier recovery of Pacific Oyster production in Australia given the presence of POMS through the rescue, assessment and protection of POMS free, resistant family lines at the onset of the Tasmanian outbreak. • Potential contribution to reduced future production losses for Pacific Oysters farmed in POMS affected areas, and non-POMS affected areas, through the identification of elite resistant family lines and industry use of the breeding calculator tool. • Improved community well-being through the regional spill-over effects of the recovery and maintenance of the Australian Pacific Oyster industry in POMS affected areas.

Project Investment

Nominal Investment

Table 2 shows the annual investment (cash and in-kind) in project 2015-232 by FRDC. The project was 100% funded by FRDC.

Table 2: Annual Investment in the Project 2015-232 (nominal $)

Year ended 30 June	**FRDC ($)**	**OTHER ($)**	**TOTAL ($)**
2016	49,700	0	49,700
Totals	49,700	0	49,700

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 (1.122). This multiplier was estimated based on the share of ‘employee benefits’ and ‘supplier’ expenses’ in total FRDC expenditure (5-year average) reported in the FRDC’s Cash Flow Statement (FRDC, 2013-2017). This multiplier then was applied to the nominal investment by FRDC shown in Table 2.

Real Investment and Extension Costs

For the purposes of the investment analysis, the investment costs of all parties were expressed in 2017/18 dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2018). No additional costs of extension were included as the project included a high level of industry involvement (e.g. information disseminated to commercial hatcheries in conjunction with clean ASI broodstock) and regular industry communication in the form of industry newsletters, ASI newsletters and presentation of project activities and outputs at industry seminars.

Impacts

Table 3 provides a summary of the principal types of impacts from project 2015-232 investment. Impacts have been 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 2015-232

Economic	• Potential contribution to an earlier recovery of Pacific Oyster production in Australia given the presence of POMS through the rescue, assessment and protection of POMS free, resistant family lines at the onset of the Tasmanian outbreak. • Potential contribution to reduced future production losses for Pacific Oysters farmed in POMS affected areas, and non-POMS affected areas, through the identification of elite resistant family lines and industry use of the breeding calculator tool.
Environmental	• Nil
Social	• Improved community well-being through the regional spill-over effects of the recovery and maintenance of the Australian Pacific Oyster industry in POMS affected areas.

Public versus Private Impacts

Major impacts identified in this analysis are private impacts. Industry related impacts (private) include faster recovery of Australian Pacific Oyster production in POMS affected areas and reduced future production losses for the Pacific Oyster industry because of the availability of POMS free breeding stock, resistant oyster stock and appropriate family selection. A social impact was also identified and may be realised through regional community spill-overs.

Distribution of Private Impacts

Benefits from private impacts will be captured by Australian Pacific Oyster hatcheries and farms. Benefits would be distributed according to associated supply and demand elasticities along the oyster industry supply chain.

Impacts on other Australian industries

There is no evidence of POMS affecting any other marine species (Dakis, 2016). Therefore, it is assumed that project impacts will be confined to the Australian Pacific Oyster industry.

Impacts Overseas

No significant benefits to overseas parties are expected, with the possible exception where knowledge related to the breeding of POMS resistant oyster varieties may be shared with other countries (e.g. POMS affected Pacific Oyster industries such as in New Zealand).

Match with National Priorities

The Australian Government's Science and Research Priorities and Rural RD&E priorities are reproduced in Table 4. The project findings and related impacts will contribute primarily to Rural RD&E Priorities 1 and 2, and to Science and Research Priority 1.

Table 4: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities (est. 2015)	**Science and Research Priorities (est. 2015)**
1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D	1. Food 2. Soil and Water 3. Transport 4. Cybersecurity 5. Energy and Resources 6. Manufacturing 7. Environmental Change 8. Health

Sources: (DAWR, 2015) and (OCS, 2015)

Valuation of Impacts

Impacts Valued

Analyses were undertaken for total benefits that included future expected benefits. A degree of conservatism was used when finalising assumptions, particularly when some uncertainty was involved. Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria.

One key impact of the project was valued. This was the investment's contribution to an earlier recovery of Pacific Oyster production in Australia given the presence of POMS.

Impacts Not Valued

Not all impacts identified in Table 3 could be valued in the assessment. The economic impact from the investment's contribution to potentially reduced future production losses was not valued due to the uncertainty associated with the probability of future POMS outbreaks both spatially and temporally. The social impact was hard to value because of a lack of evidence/data, difficulty in quantifying the causal relationships and pathways between the project investment and the impact, and the complexity of assigning monetary values to the social impact.

The economic impact identified but not valued included:

- The investment's contribution to reduced future production losses for Pacific Oysters farmed in POMS affected areas, and non-POMS affected areas, through the identification of elite resistant family lines and industry use of the breeding calculator tool.

The social impact identified but not valued included:

- Improved community well-being through the regional spill-over effects of the recovery and maintenance of the Australian Pacific Oyster industry in POMS affected areas.

Valuation of Impact 1: Earlier recovery of Pacific Oyster production

The valuation of the impact of an increased rate of recovery for Pacific Oyster production given the presence of POMS in Australia centres on the current trend in production following the discovery of POMS in Australia in NSW in 2010.

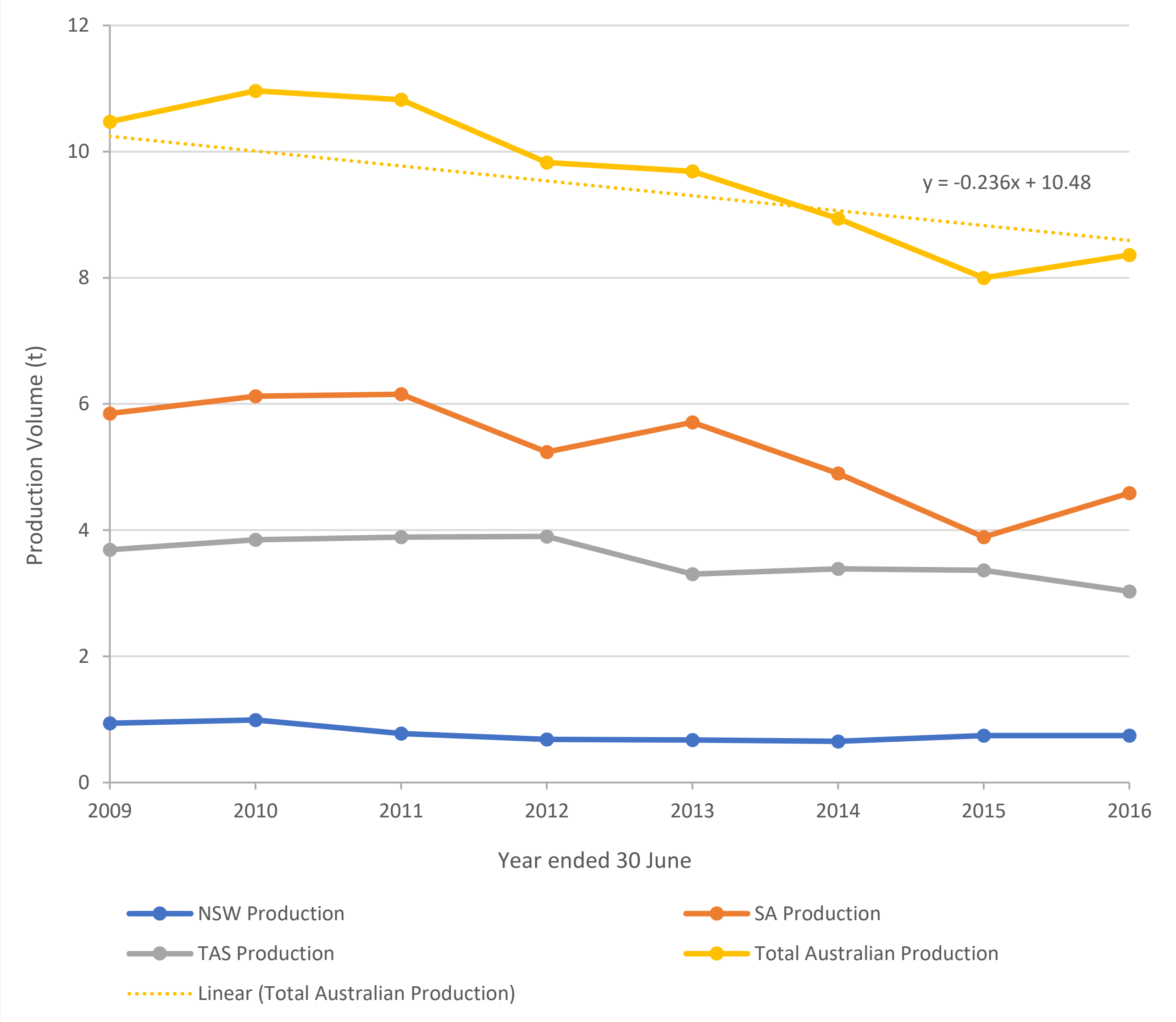
Prior to the first POMS outbreak, Australia's average Pacific Oyster production was approximately 10,800 tonnes per annum (average production for 2006/07 to 2009/10 based on the ABARES aquaculture statistics). Since the outbreak of POMS, Pacific Oyster production declined to around 8,000 tonnes in 2015 and 2016. Figure 1 shows the production of Pacific Oysters by state in Australia for the period 2009 to 2016.

Project 2015-232 has likely contributed to a faster potential recovery for Pacific Oyster production through the rescue and protection of key POMS resistant family lines. The rescue and quarantine of POMS free breeding stock with advanced genetic resistance to POMS allowed ASI to continue to supply clean and increasingly resistant spat to Australian Pacific Oyster producers during and after the 2016 Tasmanian POMS outbreak.

It was assumed that Pacific Oyster production in regions affected by POMS (i.e. NSW and Tasmania) would begin to recover from 2017/18 (Wayne Hutchinson, pers. comm., 2018) from the lower production volumes observed in 2015 and 2016 (see Figure 1) through the adoption of resistant varieties released through the ASI breeding program.

Specific assumptions for valuing Impact 1 are provided in Table 5.

Figure 1: Australian Pacific Oyster Production by State (2009 to 2016)



Attribution

It was assumed that 50% of the impact valued was attributed to the investment in project 2015-232. The increasingly resistant Pacific Oyster varieties produced by 2017/18 were assumed to be the result of a combination of the maintained availability of elite POMS resistant broodstock assessed and protected through project 2015-232 and other factors specific to the ASI breeding program and prevailing Pacific Oyster industry production environment.

Counterfactual

It was assumed that, if project 2015-232 had not been funded, given the 2016 Tasmanian POMS outbreak, progress in POMS resistance for the ASI Pacific Oyster breeding program would have been set back at least one year and the downward trend in Australian production evident since 2010 (first Australian POMS outbreak in NSW, see Figure 1) would have continued during this period as ASI would not have been able to supply industry with sufficient POMS free broodstock (Matthew Cunningham, pers. comm., 2018).

Summary of Assumptions

A summary of key assumptions made for valuation of the impacts is shown in Table 5.

Table 5: Summary of Assumptions

Variable	Assumption	Source
General Information/Data		
Average Pacific Oyster production pre-2011 (prior to POMS outbreak in Australia)	10,820 tonnes	Based on ABARES statistics (2009-2016) – note: Pacific Oysters make up approximately 20% of NSW edible oyster production only (Marine Discovery Centres Australia, 2012)
Average gross value of Pacific Oysters	$6,321/tonne	
Proportion of Pacific Oyster production in POMS affected states	45% (based on NSW and Tasmanian production as a proportion of total Australian production)	
Profit as a proportion of gross value for Pacific Oysters	10%	Agtrans Research
Baseline Australian pacific oyster production trend equation for the period 2008/09 to 2015/16	Production (.000s t) = -0.236x + 10.48 (Note: year 2008/09 is x = 0)	See Figure 1. Based on ABARES statistics (2009-2016)
Impact 1: Earlier Recovery of Australian Pacific Oyster Production		
Production recovery commences	2017/18	Wayne Hutchinson, pers. comm., 2018
Year production recovers to pre-2011 average volume	2021/22	5 years after release of ASI resistant broodstock
Attribution of impact to Project 2015-232	50%	Agtrans Research
Counterfactual		
Production recovery commences	2018/19	One-year delay in recovery due to breeding program setback in Tasmania
Year production recovers to pre-2011 average volume	2022/23	5 years after delayed release of ASI resistant broodstock

Results

All costs and benefits were discounted to 2017/18 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 project investment period plus 30 years from the last year of investment (2015/16) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2014).

Investment Criteria

Tables 6 and 7 show the investment criteria estimated for different periods of benefits for the total investment and the FRDC investment respectively. The investment criteria for the FRDC investment alone are the same as for the total investment as FRDC represented 100% of the investment in project 2015-232.

Table 6: Investment Criteria for Total Investment in Project 2015-232

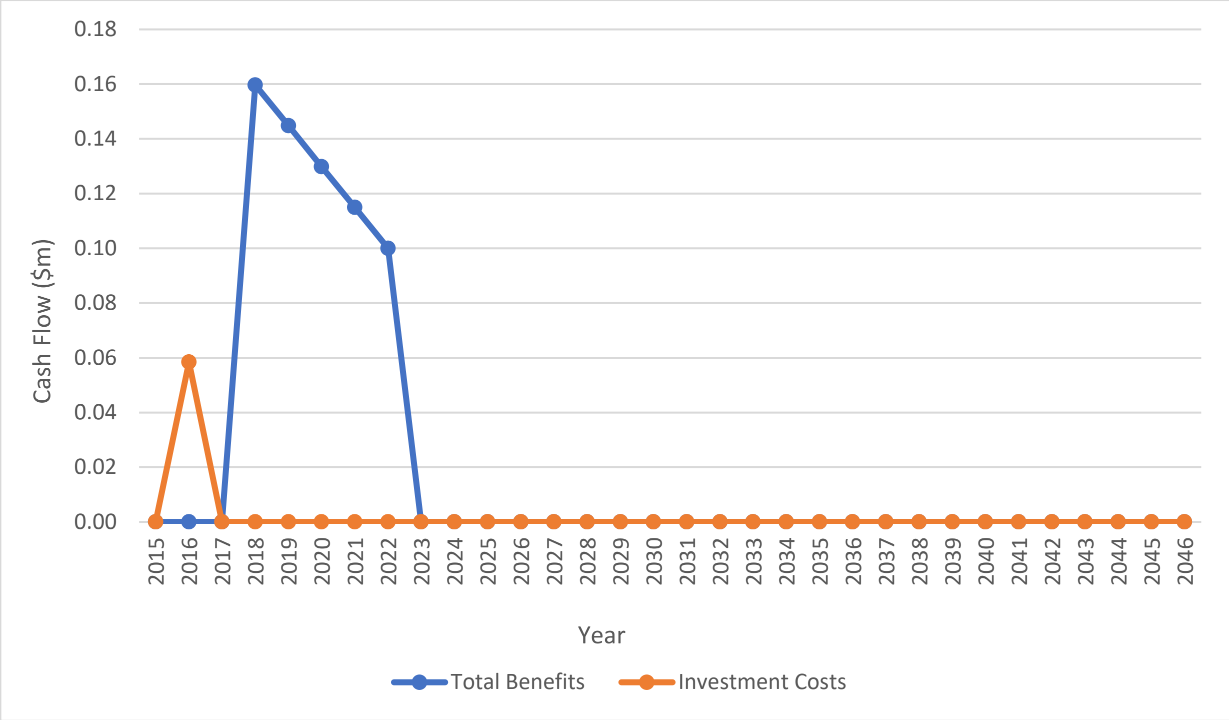
Investment Criteria	**Years after Last Year of Investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.00	0.51	0.60	0.60	0.60	0.60	0.60
Present Value of Costs ($m)	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Net Present Value ($m)	-0.06	0.45	0.53	0.53	0.53	0.53	0.53
Benefit-Cost Ratio	0.00	7.99	9.27	9.27	9.27	9.27	9.27
Internal Rate of Return (%)	negative	113.9	115.4	115.4	115.4	115.4	115.4
MIRR (%)	negative	59.1	31.2	21.8	17.4	14.8	13.1

Table 7: Investment Criteria for FRDC Investment in Project 2015-232

Investment Criteria	**Years after Last Year of Investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.00	0.51	0.60	0.60	0.60	0.60	0.60
Present Value of Costs ($m)	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Net Present Value ($m)	-0.06	0.45	0.53	0.53	0.53	0.53	0.53
Benefit-Cost Ratio	0.00	7.99	9.27	9.27	9.27	9.27	9.27
Internal Rate of Return (%)	negative	113.9	115.4	115.4	115.4	115.4	115.4
MIRR (%)	negative	59.1	31.2	21.8	17.4	14.8	13.1

The annual undiscounted benefit and cost cash flows for the total investment for the duration of the project 2015-232 investment 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 Investment 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 low sensitivity to the discount rate. This is largely because the expected benefits fall in the short to medium term future and are therefore not subjected to heavy discounting.

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

Investment Criteria	**Discount rate**		
	0%	**5% (base)**	**10%**
Present value of benefits ($m)	0.65	0.60	0.55
Present value of costs ($m)	0.06	0.06	0.07
Net present value ($m)	0.59	0.53	0.48
Benefit-cost ratio	11.12	9.27	7.83

A sensitivity analysis was undertaken for the assumption of the attribution to project 2015-232 as was a variable with some uncertainty. The results, reported in Table 9, show that the investment criteria reported have a high sensitivity to the probability of impact. However, results were still positive at an attribution level of just 10%.

Table 9: Sensitivity to the Assumed Attribution to Project 2015-232
(Total investment, 30 years)

Investment Criteria	**Attribution to Project 2015-232**		
	10%	**50% (base)**	**100%**
Present value of benefits ($m)	0.12	0.60	1.19
Present value of costs ($m)	0.06	0.06	0.06
Net present value ($m)	0.05	0.53	1.13
Benefit-cost ratio	1.85	9.27	18.54

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 to high as the impact valued represented the most significant and direct impact of the project 2015-232 investment (earlier recovery of Australian Pacific Oyster production through protection of the breeding stock). On the other hand, while the assumptions were partially supported by the project findings, consultation with the PI and various public reports, the levels assumed for the time to recovery, maximum recovery production volume and probability variables are somewhat uncertain and therefore confidence was considered to be medium-low.

Conclusions

The relatively small total investment in this project has demonstrated the significant potential impact of coordinated and timely responses to disease outbreaks for Australian aquaculture industries. Investment in project 2015-232 likely contributed to the preservation of key, POMS resistant Pacific Oyster broodstock that enabled ASI to continue to supply POMS free, and increasingly POMS resistant, spat to Australian Pacific Oyster producers.

Also, the project helped to avoid the loss of genetic gains in POMS resistance through the assessment, recovery and protection of elite family lines.

Funding for the Project Group totalled $0.06 million (present value terms) and produced estimated total expected benefits of $0.6 million (present value terms). This gave a net present value of $0.53 million, an estimated benefit-cost ratio of 9.3 to 1, an internal rate of return of 115.4% and a modified internal rate of return of 13.1%.

While a number of economic and social impacts identified were not valued, the linkages between the project and these impacts were weak and their impacts were considered uncertain and minor compared with the impacts valued. Nevertheless, combined with conservative assumptions for the impacts valued, investment criteria as provided by the valued impacts may be underestimates of the investment performance.

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.

References

Australian Bureau of Agricultural and Resource Economics and Sciences. (2009-2017). *Australian Fisheries and Aquaculture Statistics.* Canberra: Australian Bureau of Agricultureal and Resource Economics and Sciences. Retrieved from http://data.daff.gov.au/data/warehouse/9aam/afstad9aamd003/2016/AustFishAquacStats_2016_v1.0.0.pdf

Australian Bureau of Statistics. (2018, January 31). *5204.0 - Australian System of National Accounts, 2016-17.* Retrieved from Australian Bureau of Statistics: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5204.02016-17?OpenDocument

Australian Seafood Industries. (2015a). *Who We Are*. Retrieved from ASI Thoroughbred Oysters: http://www.asioysters.com.au/who-we-are.html

Australian Seafood Industries. (2015b). *Breeding Program*. Retrieved from ASI Thoroughbred Oysters: http://www.asioysters.com.au/breeding-program.html

Biosecurity Tasmania. (2018, April 26). *Pacific Oyster Mortality Syndrome (POMS)*. Retrieved from Tasmanian Government - Biosecurity Tasmania: http://dpipwe.tas.gov.au/biosecurity-tasmania/aquatic-pests-and-diseases/aquatic-biosecurity-threats/poms

Council of Rural Research and Development Corporations. (2014). *Impact Assessment Guidelines.* Canberra: Council of Rural Research and Development Corporations. Retrieved from http://www.ruralrdc.com.au/wp-content/uploads/2016/04/CRRDC-Impact-Assessment-Guidelines-V.1-070514.pdf

Dakis, S. (2016, February 18). *POMS-resistant oysters provide a future for the Australian industry, say marine researchers*. Retrieved from ABC News: http://www.abc.net.au/news/rural/2016-02-17/poms-resistant-oysters-tasmania/7177808

Department of Agriculture and Water Resources. (2015). *Agricultural Competitiveness White Paper.* Canberra: Commonwealth of Australia. Retrieved from http://agwhitepaper.agriculture.gov.au/SiteCollectionDocuments/ag-competitiveness-white-paper.pdf

Fisheries Research and Development Corporation. (2013 to 2017). *Annual Report.* Canberra: Fisheries Research and Development Corporation.

Marine Discovery Centres Australia. (2012). *Plankton to Plate - The story of edible oysters.* Retrieved from Marine Discovery Centres Australia: https://www.mdca.org.au/wp-content/uploads/2012/06/OysterFunkyFacts_FactSheets.pdf

New South Wales Department of Primary Industries. (n.d.). *Pacific Oyster Mortality Syndrome (POMS).* Retrieved from NSW Department of Primary Industries - Pests & diseases: https://www.dpi.nsw.gov.au/fishing/pests-diseases/animal-health/aquaculture/poms

Office of the Chief Scientist. (2015). *Strategic Science and Research Priorities.* Canberra: Commonwealth of Australia. Retrieved from http://www.chiefscientist.gov.au/wp-content/uploads/STRATEGIC-SCIENCE-AND-RESEARCH-PRIORITIES_181214web.pdf