FINAL

An Impact Assessment of FRDC Investment in 2013-051: The Australian Aquatic Animal Health and Vaccine Centre: First Phase to Establish Atlantic Salmon Biosecure Fish Facility Capabilities and Develop Strategy for an Australian Centre of Excellence

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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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Jeremy Carson - Principal Research Microbiologist, Department of Primary Industries, Parks, and Water Resources

Abbreviations

AAHVCoE	Aquatic Animal Health and Vaccines Centre of Excellence
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
AHL	Animal Health Laboratories
CAD	Canadian Dollar
CRRDC	Council of Rural Research and Development Corporations
DAWR	Department of Agriculture and Water Resources
DPIPWE	Department of Primary Industries, Parks and Water Resources
FRDC	Fisheries Research and Development Corporation
IPA	Industry Partnership Agreements
KR	Norwegian Krone
OCS	Office of the Chief Scientist
POMV	Pilchard Orthomyxovirus
PVB	Present Value of Benefits
R&D	Research and Development
RD&E	Research, Development and Extension
SCRC	Seafood Cooperative Research Centre
TABV	Tasmanian Aquabirnavirus
TRLO	Tasmanian Rickettsia-like organism
TSGA	Tasmanian Salmon Growers Association
USD	United States Dollar

Executive Summary

What the report is about

This report presents the results of an impact assessment of the Fisheries Research and Development Corporation (FRDC) investment in a project to build a world-class vaccine Centre of Excellence to research Atlantic Salmon vaccines. The project was funded by FRDC and others in the years ending 30th June 2014, 2015 and 2016.

Methodology

The investment in the project was analysed qualitatively within a logical framework that included activities/outputs, outcomes, and impacts. Identified impacts were then categorised into a triple bottom line framework. Principal impacts from those identified were then valued. Benefits were estimated for a range of time frames up to 30 years from the year of last investment in the project. Past and future cash flows in 2017/18 $ terms were discounted to the year 2017/18 using a discount rate of 5% to estimate the investment criteria.

Results/key findings

The major impact identified and valued was an improved capacity to research salmon vaccines, in turn driving lower mortality rates through an increased number of vaccines developed.

Investment Criteria

Funding for the project over the three years totalled $4.45 million (present value terms) and produced estimated total expected benefits of $67.13 million (present value terms). This gave a net present value of $62.68 million, a benefit-cost ratio of 15.09 to 1, an internal rate of return of 32.1% and a modified internal rate of return of 14.6%.

Conclusions

The investment in this project has resulted in the ability to research vaccines required for the Tasmanian salmon industry faster and so producing lower mortality rates for salmon.

Keywords

Impact assessment, cost-benefit analysis, fish diseases, Atlantic salmon, *Salmo salar*, salmonids, vaccine development, bacterial vaccines, viral vaccines, biosecurity, biocontainment, research facilities, aquaculture, disinfection

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 2013-051: *The Australian Aquatic Animal Health and Vaccine Centre: First Phase to Establish Atlantic Salmon Biosecure Fish Facility Capabilities and Develop Strategy for an Australian Centre of Excellence* 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, 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

The Animal Health Laboratory (AHL) at the Tasmanian Department of Primary Industries, Parks, Water and Environment (DPIPWE) has been involved in dialogistic services since the 1980s. In 1993 the Fish Health Unit was established at the AHL to help service aquaculture production. The Fish Health Unit has helped develop fish vaccines a number of which are used in Tasmanian farmed Atlantic salmon (hereafter referred to as salmon) production.

With the on-going expansion of the salmon aquaculture industry and a continued focus on vaccine development, the industry has undertaken multiple projects and investigations associated with vaccines. For example, three projects were focusing on the development of vaccines against the Tasmanian *Rickettsia*-like organism (FRDC 2011/223), the Tasmanian aquabirnavirus (FRDC 2010/032) and the Tasmanian Atlantic salmon aquareovirus (FRDC 2011/224). All these projects required access to tank facilities at the AHL, but tank-time was limited because only one test system was available constraining research. Further pressure on resources occurs from commitments to undertake mandated vaccine safety testing on batches of vaccine produced commercially for third-party manufacturers supplying vaccines to the Tasmanian salmon industry.

There are significant risks of salmon disease for the Australian salmon industry. Disease outbreaks overseas have caused substantial production losses, for example, infectious salmon anaemia virus has led to losses valued at $CAN 20 million in Canada. KR100 million in Norway, £20 million in Scotland, and $USD 2 billion in Chile. The infectious salmon anaemia virus was able to be controlled through vaccine development.

There are resource limitations to the development of fish vaccines in Australia. The Australian salmon industry did not have a specialised vaccination research centre exclusively for aquaculture disease. Priority vaccination research was done on an ad-hoc basis (Jeremy Carson, pers. comm., 2018) and was dependent on available resources.

Importation of vaccinations is not an available option, as there are strict import conditions for vaccines, leading to significant delays. There was also a backlog of vaccine research because of other priority research that needed to be undertaken. The Australian salmon industry was incurring production losses due to the delays in researching vaccines, gaining approval and making them available.

FRDC and Tasmanian Salmon Growers Association (TSGA) planned to invest approximately $30 million in vaccine research and development (R&D), so needed the capacity and facilities to carry out the planned research. Under the FRDC/TSGA research and development plan, one of the main pillars was the development of an Aquatic Animal Health and Vaccines Centre of Excellence (AAHVCoE).

As the Australian salmon industry was expanding, there was an increase in disease risk. Vaccination could provide an effective form of treatment as an alternative management option; the use of antibiotics was costly and eroded the social-licence to operate for the Australian salmon industry.

By building a specialised vaccination research centre, the industry planned to respond to disease threats faster and be able to research vaccines to address more than one disease simultaneously.

Project Details

Summary

Project Code: 2013-051

Title: *The Australian Aquatic Animal Health and Vaccine Centre: First Phase to Establish Atlantic Salmon Biosecure Fish Facility Capabilities and Develop Strategy for an Australian Centre of Excellence*

Research Organisation: Department of Primary Industries, Parks, Water and Environment – Tasmania

Principle Investigator: Jeremy Carson

Period of Funding: January 2014 - October 2016

FRDC Programs Allocation: Industry (100%)

Objectives

The objectives of the project were:

1. Establish Australia's first biosecure test facility for the research and development of commercial-ready bacterial and viral vaccines to control diseases in fish.
2. Establish a high capacity, certified waste treatment plant for Australia's first biosecure facility for the research and development of bacterial and viral fish vaccines.
3. Upgrade the research facilities at the Animal Health Laboratory including a vaccine fermenter suite for the development of prototype bacterial and viral vaccines, and a virology suite for disease diagnosis and to support the development of viral vaccines.
4. Investment in specialist scientists to accelerate the development of bacterial and viral vaccines and technical staff to manage the operation of the biosecure fish facility.

Logical Framework

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

Table 1: Logical Framework for Project 2013-051

Activities and Outputs	• The AHL in Launceston, Tasmania was chosen as the site for the new fish health and vaccine facility. The AHL was selected because of the experience of the existing AHL staff in dealing with fish trials and vaccines and having the veterinary skills required for handling animals exposed to pathogens. The AHL was also home to the Fish Health Unit at the DPIPWE. The specific site chosen was previously DPIPWE's animal yard, which was no longer in operational use. • The Aquatic Animal Health and Vaccines Centre of Excellence (AAHVCoE) was designed to research potential new vaccines for the aquaculture industry. With limited capacity before the AAHVCoE initiative, there was a backlog of research to be undertaken. • The AAHVCoE was funded by the State Government of Tasmania (through DPIPWE), the TSGA, and FRDC. There was additional funding from the Seafood

	Cooperative Research Centre (SCRC) for a fifth holding room through FRDC Project 2014/712. The initial phase for the AAHVCoE was funded through significant investment by the three partners in laboratory and fish holding infrastructure to enable expanded diagnostic and research activities. • The AAHVCoE facility built was approximately 350m^2 in area. The facility includes five holding rooms, each with 12, 1,000L holding tanks, a biofilter conditioning room, and other emergency and staff facilities. Each of the holding tanks also has their own biofiltration system and temperature control, allowing for operation in either fresh or salt water. • The tanks' design system and fish holding rooms were based on the designs from FRDC Project 2010/032 on tank systems. The same tank design system has been used also in FRDC Projects 2011/223 and 2012/053, proving the design system was appropriate for the AAHVCoE. • The design implementation was affected by the project staff in conjunction with Huon Aquaculture, Petuna, and the Tassal Group. • The sea and freshwater facilities were built to enable rigorous testing of vaccines to all conditions. The facilities were designed so that freshwater and seawater experiments could occur simultaneously. • The facility was certified by the Department of Agriculture and Water Resources (DAWR) to allow importation of cell lines for *in vivo* trials, with approval given in October 2015. The AAHVCoE also passed the follow-up audit on 22nd February 2016. • The certification allows the facility to work with Risk Group Two viruses. Risk Group Two viruses are the principal pathogens that cause disease in aquaculture. • A five-year strategic plan for the AAHVCoE was developed by a steering committee made up of various stakeholders from government, researchers, and industry. • A five-year research program was developed for the AAHVCoE with five different research lines. The research program extends or enhances current FRDC projects working on salmon vaccines. Examples include FRDC Project 2010/032, 2011/224, 2011/223, and 2013/033. The program included also the development of other vaccines based on Centre agreed funding, other short-term projects and a vaccine safety testing program. • The project also established a waste treatment plant for the AAHVCoE. As vaccine-related R&D creates viral and vaccine waste, the waste treatment plant was constructed to ensure fish pathogens are not released into the environment. • Water testing was carried out to ensure compliance with AS/NZ 4276.3.1:2007, to ensure water is being disinfected. The testing revealed the wastewater treatment system was meeting the required standards. • The wastewater treatment facility was deemed compliant with the Building Code of Australia, local by-laws, and AS/NSZ standards. The discharge of wastewater was approved by TasWater. These standards ensured the facility could handle infectious agents to perform research. • Following identification of a need for further special laboratories to ensure that the research objectives of the AAHVCoE could be met, a fermenter laboratory, a cell culture laboratory, and a virology laboratory were established. • A molecular virologist, three research microbiologists, and four research technicians were hired after the construction of the facility to increase capacity for the AAHVCoE and the Fish Health Unit. • The construction and successful opening of the AAHVCoE in August 2015 were showcased in The Examiner newspaper. The article described the facility and the potential benefits of its future research.
Outcomes	• The salmon industry in Tasmania now can take future preventative action to combat potential diseases due to increased research infrastructure capacity. The

	industry can also respond more quickly to any new disease that occurs in Tasmania and elsewhere in Australia. • The AAHVCoE can undertake multiple projects at once (testing and developing vaccines). This has allowed faster processing of vaccines, avoiding possible research and development bottlenecks that have been restrictive in the past. The AAHVCoE can process vaccines five times faster than previously (Main, 2016). • Creation of the AAHVCoE means that researchers now can develop prototype viral vaccines. Establishing a capacity to develop viral vaccines in Tasmania means the complexity of development and importation of vaccines from overseas is avoided. • More advanced vaccine development approaches can be undertaken because of the AAHVCoE being built (Jeremy Carson, pers. comm., 2018). • The AAHVCoE has already developed the Tegovac® vaccine under FRDC Project 2014/712. The Tegovac® vaccine has been in use in the Tasmanian salmon industry since early 2017 (Jeremy Carson pers. comm., 2018). • The Certovac™ was developed under FRDC Project 2016/054 by the AAHVCoE for the Pilchard Orthomyxovirus (POMV). • The previously suspended research into the Tasmanian Rickettsia-like organism (TRLO) vaccine and the Tasmanian Aquabirnavirus (TABV) vaccine can continue due to the facility being built. This was integrated with extensions of FRDC Projects 2011/223 and 2010/032. Extension of FRDC research into the Tasmanian Atlantic salmon aquareovirus (FRDC 2011/224) can also take place. This has allowed research that was scheduled previously to go ahead as planned with the projects being run in parallel rather than sequentially. • The salmon industry can adequately respond to the outbreak of POMV due to the construction of the AAHVCoE, allowing research into a vaccine to take place that does not displace other research needs. • The potential has increased for other aquaculture industry diseases to be researched at the AAHVCoE when disease threats arise. • The Corrovac® vaccine that was advanced due to the AAHVCoE has been used in New Zealand. • The operating costs of the AAHVCoE are funded by the research projects that are conducted at the AAHVCoE (Jeremy Carson, pers. comm., 2018).
Impacts	• Avoided potential future salmon production losses from existing and/or new aquatic diseases because of faster vaccine processing, and improved vaccine R&D capacity and capability in Australia. • Avoided losses of other Australian aquaculture industries due to vaccines that may be developed. • Improved research effectiveness and efficiency due to the AAHVCoE being able to research different vaccines simultaneously and having a greater capacity for in-house research. • Increased animal welfare through reduction of severity of fish disease outbreaks. • Export income to Australia from the potential sale of vaccines to foreign markets. • Enhanced reputation for Australia in aquaculture disease research. • Increase in research and scientific capacity and capability through the establishment of core expertise.

Project Investment

Additional costs

The fifth holding room of the AAHVCoE was funded through the TSGA sourcing funds through the SCRC in FRDC Project 2014/712. The investment from FRDC Project 2014/712 was critical to the outcomes and impacts, as the project was funded to construct an extra holding room. The holding room cost is included in Table 2. Not all of the costs of FRDC Project 2014/712 are included, only the contribution for the building of the fifth holding room. There was also an additional $500,000 committed by DPIPWE to the AAHVCoE not included in the project budget in May 2014. (Jeremy Carson pers. comm., 2018), but included in Table 2.

There were additional in-kind costs of $60,000 to the project provided by the TSGA. These additional costs were provided by FRDC Project 2013-057.1.

Table 2 includes all costs of the project.

Nominal Investment

Table 2 shows the annual investment made in Project 2013-051 and 2013-051.1 by FRDC and others including DPIPWE, TSGA, and the SCRC.

Table 2: Annual Investment in Project 2013-051 (nominal $)

Year ended 30 June	FRDC ($)	DPIPWE ($)	TSGA ($)	SCRC ($)	TOTAL ($)
2014	1,694,600	825,000	400,000	0	2,919,600
2015	0	0	120,000	0	120,000
2016	0	0	0	298,000	298,000
Totals	**1,694,600**	**825,000**	**520,000**	**298,000**	**3,337,600**

Source: Jeremy Carson, pers. comm., 2018 and FRDC

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 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.

The cost of managing the SCRC investment in the PG also was added to the nominal SCRC contribution in Table 2 via a management cost multiplier of 1.083. This multiplier was estimated based on the total reported share of ‘employee’ and ‘supplier’ expenses in total SCRC expenditure from the SCRC’s Cash Flow Statements for the period ended 30 June 2009 to 2014 (Australian Seafood CRC, 2009 to 2014).

Real Investment and Extension Costs

For purposes of the investment analysis, the investment costs of all parties were expressed in 2017/18 $ terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2018). There are no additional extension costs associated with the investment; however, usage of the facility will be associated with additional research and extension costs.

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 2013-051

Economic	• Avoided potential future salmon production losses from existing and/or new aquatic diseases because of faster vaccine processing, improved vaccine R&D capacity and capability in Australia. • Improved research effectiveness and efficiency due to the AAHVCoE being able to research different vaccines simultaneously and having a greater capacity for in-house research. • Avoided losses of other Australian aquaculture industries due to vaccines that may be developed in the future when other aquaculture industries increase in size. • Export income to Australia from the potential sale of vaccines to foreign markets where there are similar diseases.
Environmental	• N/A
Social	• Increased animal welfare through reduction of severity of fish disease outbreaks due to better and additional vaccines being available. • Enhanced reputation for Australia in aquaculture disease research as there is a world-class aquatic disease research centre in Australia. • Increase in research and scientific capacity and capability through the establishment of core expertise in the aquatic vaccinations field.

Public versus Private Impacts

The investment resulted in both private and public impacts. The majority of the impacts are private, but there are significant public impacts resulting from the project. Public impacts include the increased animal welfare impact through fewer disease outbreaks, increased scientific and research capacity, and enhanced reputation of Australia in aquaculture disease research. The private impacts are avoided production losses due to new vaccines being produced faster, and increased research effectiveness and efficiency due to the facilities built.

Distribution of Private Impacts

The majority of private impacts will flow to the Tasmanian salmon industry. There will be minor impacts to other aquaculture industries further into the future as industries other than salmon use the AAHVCoE for vaccine research.

Impacts on other Australian Industries

There are expected to be no significant impacts to other Australian industries outside of the Australian aquaculture industry and associated vaccine producers.

Impacts Overseas

There are no major benefits to overseas parties from this project. There may be improved salmon and aquaculture health impacts to foreign aquaculture industries because of the project. The vaccines produced by the AAHVCoE are designed for local-Australian diseases, but if these diseases appear overseas, there is scope for exporting the vaccines.

Match with National Priorities

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

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

Impact Valued

The principal impact valued is the avoided potential future salmon production losses from existing and new aquatic diseases because of faster vaccine processing, and improved vaccine R&D capacity and capability in Australia.

Impacts not Valued

Not all impacts identified in Table 3 could be valued in the assessment. The impacts not valued included:

Economic Impacts
- Improved research effectiveness and efficiency due to the AAHVCoE being able to research different vaccines concurrently and having a greater capacity for in-house research.
- Avoided losses of Australian aquaculture industries other than salmon due to vaccines that may be developed.
- Export income to Australia from the potential sale of vaccines to foreign markets.

Social Impacts
- Increased animal welfare through reduction of severity of fish disease outbreaks.
- Enhanced reputation for Australia in aquaculture disease research.
- Increase in research and scientific capacity and capability through the establishment of core expertise.

The other economic and social impacts are not valued due to being considered relatively minor compared to the main impact valued, difficulty in assigning realistic assumptions due to impacts taking place well into the future, uncertainty over a pathway to impact, and time and resource constraints.

Valuation of Impact 1: Faster development of vaccines

Vaccine production 2015/16 – 2019/20

Research projects and vaccines can be developed faster than what otherwise would have taken place because of the availability of the AAHVCoE facility. The AAHVCoE has already produced two vaccines as of July 2018.

The AAHVCoE has allowed five separate research lines to take place at once. Figure 1 outlines the research plan for 2015/16 – 2019/20. The increased capacity due to the facilities built already has allowed faster testing of vaccines. For example, the Tegovac vaccine testing has taken three months to complete, compared to 12 months with the previous facilities (Jeremy Carson, pers. comm., 2018).

With the current five-year plan, each of the four vaccines produced are assumed to save 1% of annual salmon production within a year of release of the produced vaccine. All vaccines produced are assumed to be successful at reducing mortality. The assumption is that losses apply to salmon at full development and that the entire industry uses the vaccines developed by the AAHVCoE. The saved salmon production is a conservative estimate as there may be higher mortalities for specific diseases, and it is unknown at what stage of the growth cycle the mortalities would take place. Salmon that are killed by diseases are assumed not sold on the market. The gross value of salmon produced per annum

is $704.4 million, with 54,772 tonnes being harvested (ABARES, 2017). It is assumed that the production and value of salmon is constant into the future.

As information exists for the likely timing for production and use of vaccines produced within the current research plan, this information is used for assumptions for valuing the impact over the first five years. It is assumed that the Tegovac vaccine developed in 2017/18 is first used in 2018/19. The TABV, Tasmanian Atlantic salmon Reovirus, and POMV vaccines are expected to be complete in either 2017/18 and 2018/19. One vaccine is assumed available in 2017/18, while another is assumed to be available in 2018/19, while another is available in 2019/20. The first year of benefits accruing to these vaccines are in the years when they are first available.

The AAHVCoE research plan shown in Figure 1, identifies the future research taking place at the AAHVCoE.

Figure 1: Five-year Plan of the AAHVCoE (2015/16 - 2019/20)

Program	2015/16	2016/17	2017/18	2018/19	2019/20
1	(1) Recurrent Vaccine Safety Testing Program (2) Short projects				
2	**AAHVCoE** Efficacy testing of Tegovac, a tetravalent vaccine for *Aeromonas salmonicida*, *Vibrio anguillarum* and *Yersinia ruckeri* biotypes 1 an 2	**FRDC 2011/223** Completion of efficacy testing of multivalent formulation of Corrovac	**FRDC 2010/032** Completion of Tasmanian Aquabirnavirus (TABV) vaccine development and assessment of multivalent vaccine formulations incorporating TABV		Projects to be identified and approved by the RSC
3	**FRDC 2013/033** Development of diagnostics for pilchard orthomyxovirus (POMV) and establishment of a diagnostic capacity for fish virology	**FRDC 2011/224** Development of a vaccine for the Tasmanian Atlantic salmon Reovirus (TSRV) and assessment of multivalent vaccine formulations incorporating TSRV			Projects to be identified and approved by the RSC
4	**AAHVCoE** Development of a vaccine for the Pilchard Orthomyxovirus by December 2018			**AAHVCoE** Assessment of multivalent vaccine formulations incorporating POMV	Projects to be identified and approved by the RSC
5	**AAHVCoE** (1) Support the industry selective breeding program (SBP) – disease resistance assessment. Trials as identified and approved by the RSC (2) *Yersinia ruckeri* vaccine R&D Program • Oral vaccine development and commercialisation • Vaccine efficacy assessment based on bivalent dip vaccine incorporating Biotype 1 and Biotype 2 strains • Develop challenge model for Biotype 2 strain • Cross-protection studies for the three serotypes that occur in Tasmania: O1b, O1 (biotype 2) and O2 • Evaluation of dip adjuvant (Montanide IMS 1312VG) for the Yersinivac-B dip vaccine				

Colour Key

	Live project in progress		FRDC Legacy projects		Centre Agreement funding		Safety testing or short projects

Vaccine production from 2020/21

In response to a backlog of research, there was an immediate need to construct the AAHVCoE to clear the backlog of research. After the five-year plan, there may not be as much work to be undertaken at the AAHVCoE. Fewer successful vaccines or successful vaccines updates will be produced compared to earlier. The current valuation assumes that there will be three vaccines or vaccine updates to take place every five years (or 0.6 vaccines to be produced every year). The successful vaccines produced are assumed to save 1% of the gross value of Tasmanian salmon per vaccine. Other aquaculture industries may use the excess capacity, but the other industries use is considered a non-valued impact.

Twenty years after the AAHVCoE opening, it is assumed that the AAHVCoE capital will need to be renewed. The benefits after 2037 are assumed to zero as a new project will need to be funded to replace the capital of the AAHVCoE. There are benefits beyond 2037, as the research produced before will still have benefits to industry.

Operating costs

Projects funded as part of the FRDC-TSGA Industry Partnership Agreements (IPA) (Jeremey Carson, pers. comm., 2018) cover the operating costs of the AAHVCoE. It is assumed that into the future the operating costs of the AAHVCoE are covered by the research being funded for the vaccine research at the AAHVCoE. Annual costs for running the FRDC projects (2014-712, 2016-054,2013-033, 2011-224, 2016-045, and 2017-128) involved with the AAHVCoE are currently $2,008,752 per year. The cost of the research projects is assumed between 2015/16 to 2019/20. The analysis included all in-kind costs of the projects run at the AAHVCoE.

The TSGA have stated they plan to use the AAHVCoE at least until 2020. After the strategic plan has finished in 2020, further research is assumed to take place to fund future operating costs.

The costs after 2019/20 are proportional to the number of vaccines produced by the AAHVCoE. As post 2019/20 assumes 0.6 vaccines are produced per year, the cost per year of developing vaccines is $1,506,564.

Future disease risk is inherently unknown, but due to the history of salmon aquaculture worldwide having diseases as a persistent problem. Into the future, the operation of the AAHVCoE is assumed to continue.

Manufacturing and vaccination costs are assumed to be allowed for in the 1% value loss estimate. Any other management costs avoided (e.g. antibiotic use) are also allowed for in the 1% value loss avoided.

Counterfactual

It is assumed that the vaccines produced by the AAHVCoE would have been produced without the centre but at a later date. There would have been a priority given to diseases that pose a substantial financial or immediate threat, over other vaccines. Under the previous arrangements, it is assumed there would have been a more reactive program rather than pro-active.

Research would have been conducted into the future as previously. This assumption is based on the fact that DPIPWE already undertook vaccine development, but it was an ad hoc arrangement with limited resources (Jeremy Carson, pers. comm., 2018). The POMV vaccine, Tegovac™, TABV, and other vaccines would have been produced without the project but would have come to market at a later date.

There still would be the capacity to develop vaccines in the absence of the AAHVCoE. Under previous arrangements, there would only be one successful vaccine produced or upgraded every two years (half a vaccine a year). The cost of producing the vaccines without the AAHVCoE is assumed to cost $1,255,470 per year.

The assumptions in the counterfactual and the ‘with’ project scenario are assumed the same, apart from the number of vaccines produced and the cost of researching and developing vaccines.

Attribution

The benefits from developing the vaccines from the facility need to be attributed to both the existence of the facility as provided by the project investment as well as the projects that fund the development of the vaccines. The attribution factor for benefits to the facility establishment was calculated by first estimating the annual capital recovery costs for the investment, assumed to be 10%. This estimate of annual capital recovery costs was added to the annual operating costs to obtain a total annual cost for

the facility. The annual capital recovery costs as a proportion of the total annual costs was used as the attribution factor for benefits of the project investment. The attribution factors for the first five years of benefits was is 15.6%, and 19.7% for the benefits after 2020.

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

Table 5: Summary of Assumptions

Variable	Assumption	Source
General Assumptions		
Production of salmon per year	54,772 tonnes	ABARES, 2017
Value of Tasmanian salmon per year	$704.4 million	ABARES, 2017
Farm gate value of salmon	$12,861 per tonne	$704.4 million/54,772 tonnes
With AAHVCoE: First Five Years		
Number of vaccines developed in the first five years (2015/16 to 2019/20)	4	Agtrans Research based on AAHVCoE five year plan
Number of vaccines developed 2018	2	Agtrans Research based on AAHVCoE five year plan
Number of vaccines developed 2019	1	Agtrans Research based on AAHVCoE five year plan
Number of vaccines developed 2020	1	Agtrans Research based on AAHVCoE five year plan
Mortality avoided per vaccine produced	1% p.a.	Agtrans Research
Potential reduction in the value of salmon deaths avoided per 0.8 vaccine developed every year	$5,630,237	(54,772 tonnes * 1%) * $12,861 * 0.8
Costs per year for research and running facility per year (2015/16 to 2019/20)	$2,008,752	Based on annual cost for running three projects (Source: Jeremy Carson, pers. comm., 2018 and Joshua Fielding pers. comm., 2018)
First year of vaccine development from five-year plan	2017/18	Agtrans Research based on AAHVCoE five-year plan
Last year of vaccine development from five-year plan	2019/20	Agtrans Research based on AAHVCoE five-year plan
Attribution factor 2015-2020	15.55%	(3,697,383*10%)/ (3,697,383*10% +2,008,752)
With AAHVCoE : Vaccine development post 2019/20		
Vaccines developed per year (2020/21 onwards)	0.6	Agtrans Research
Cost of vaccine development per year	$1,506,564	($2,008,752/0.8) * 0.6
Potential reduction in the value of salmon deaths avoided per 0.6 vaccine developed every year	$4,222,678	(54,772 tonnes*1%) * $12,861 * 0.6
First year of benefit	2020/21	Agtrans Research
Life of facility	2035/36 (20 years from 2015/16)	Agtrans Research
Attribution factor 2021 onwards	19.71%	(3,697,383 *10%)/ (3,697383*10% +1,506,564)

Counterfactual		
Vaccines produced per year	0.5	Agtrans Research
Mortality avoided per vaccine produced or upgraded	1%	Agtrans Research
Cost of vaccine development per year	$1,255,470	($2,008,752 /0.8) * 0.5
Potential reduction per annum in the value of salmon deaths avoided per 0.5 vaccine developed	$3,522,000	(54,772 tonnes*1%) * $12,861 * 0.5
FRDC Program Allocation		
Allocation to Industry program	100%	FRDC

Results

All benefits after 2017/18 were expressed in 2017/18 $ terms. 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 investment period plus 30 years from the last year of investment (2016/17) 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) attributable to the FRDC investment only, shown in Table 7, has been estimated by multiplying the total PVB by the FRDC proportion of real investment before discounting (53.20%).

Table 6: Investment Criteria for Total Investment in Project 2013-053

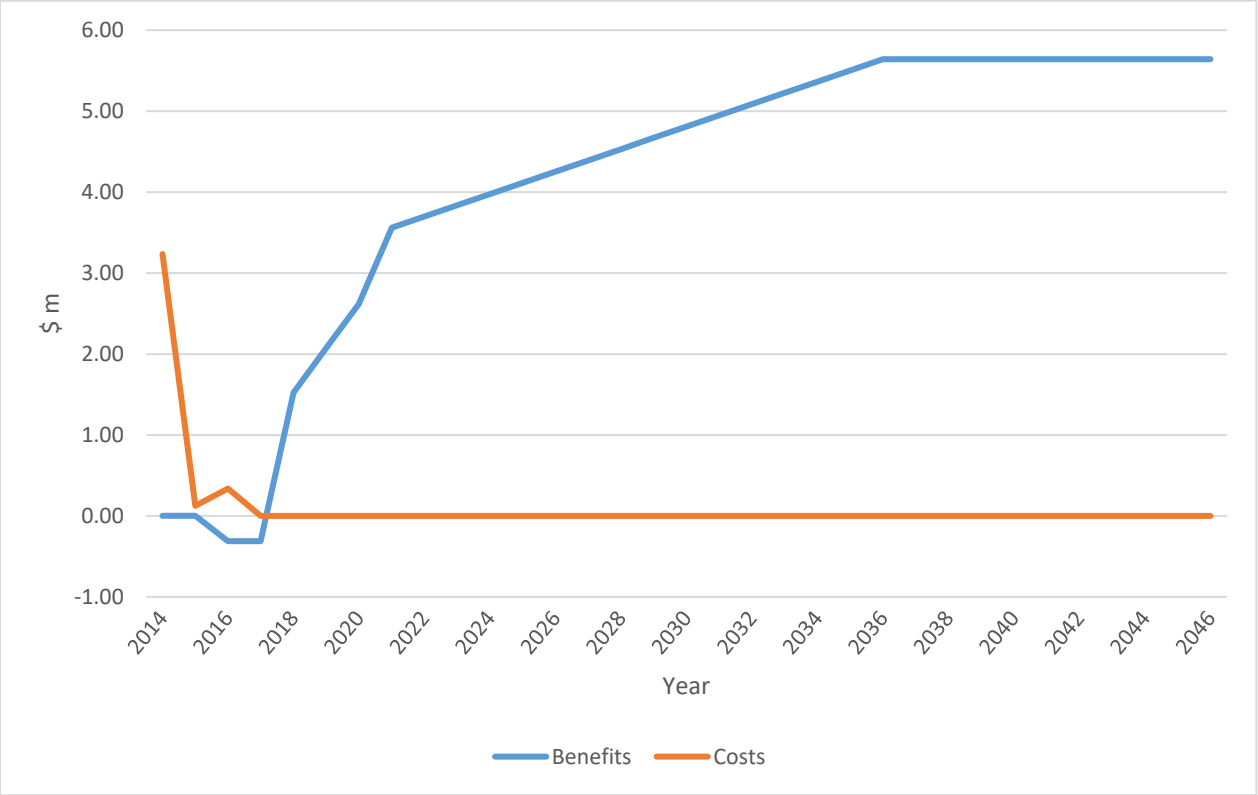
Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	-0.34	8.28	23.10	36.74	49.03	59.18	67.13
Present value of costs ($m)	4.45	4.45	4.45	4.45	4.45	4.45	4.45
Net present value ($m)	-4.79	3.83	18.65	32.29	44.58	54.73	62.68
Benefit-cost ratio	-0.08	1.86	5.19	8.26	11.02	13.30	15.09
Internal rate of return (%)	negative	16.8	29.3	31.5	32.0	32.1	32.1
Modified Internal Rate of Return (%)	negative	19.3	23.9	20.6	18.0	16.1	14.6

Table 7: Investment Criteria for FRDC Investment in Project 2013-053

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	-0.18	4.40	12.29	19.55	26.08	31.48	35.71
Present value of costs ($m)	2.39	2.39	2.39	2.39	2.39	2.39	2.39
Net present value ($m)	-2.57	2.01	9.90	17.16	23.69	29.09	33.32
Benefit-cost ratio	-0.08	1.84	5.14	8.18	10.91	13.17	14.94
Internal rate of return (%)	negative	16.2	28.5	30.7	31.2	31.4	31.4
Modified Internal Rate of Return (%)	negative	33.8	29.9	24.0	20.3	17.7	15.9

The annual undiscounted benefit and cost cash flows for the total investment for the duration of the 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 high sensitivity to the discount rate.

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

Investment Criteria	**Discount rate**		
	0%	**5% (base)**	**10%**
Present value of benefits ($m)	135.62	67.13	39.08
Present value of costs ($m)	3.70	4.45	5.31
Net present value ($m)	131.92	62.68	33.77
Benefit-cost ratio	36.68	15.09	7.36

Pessimistic and Optimistic Scenarios

A sensitivity analysis was undertaken for pessimistic and optimistic levels of the variables with the highest level of uncertainty. There was one variable subject to sensitivity analysis: the number of vaccines produced per annum post 2019/20. The results presented in Table 9 show there is minor sensitivity to the number of vaccines assumed produced post 2020.

Table 9: Sensitivity to the number of vaccines produced post 2020
(Total Investment, 30 years)

Investment Criteria	**Sensitivity to number of vaccines produced post 2020**		
	Pessimistic Vaccines produced post 2019/20 – 0.3 per year	**Most likely (Base) Vaccines produced post 2019/20 – 0.6 per year**	**Optimistic Vaccines produced post 2019/20 – 0.9 per year**
Present value of benefits ($m)	25.07	67.13	85.09
Present value of costs ($m)	4.45	4.45	4.45
Net present value ($m)	20.62	62.68	80.64
Benefit-cost ratio	5.64	15.09	19.13

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	Medium

The coverage of benefits is rated at medium. While the impact valued is the primary impact, there are significant impacts that were not valued due to lack of data, a clear pathway to valuation, and lack of time and resources.

The confidence is assumptions are rated as medium. There are a number of simplifying assumptions in the analysis that were made due to time and resource constraints. Some of the outputs and outcomes have already been delivered but there is uncertainty about future benefits as they are somewhat uncertain, and the type and number of future salmon diseases (and hence the vaccines needed) are unknown.

Conclusions

The investment in this project has resulted in the construction of the AAHVCoE.

Funding for the project over the three years totalled $4.45 million (present value terms) and produced estimated total expected benefits of $67.13 million (present value terms). This gave a net present value of $62.68 million, a benefit-cost ratio of 15.09 to 1, an internal rate of return of 32.1% and a modified internal rate of return of 14.6%.

As some of the impacts identified were not valued, and conservative assumptions used for the impacts valued, the investment criteria as provided by the valued benefit are likely to be underestimates of the investment performance. On the other hand, confidence in the assumptions for the benefit valued was considered to be only medium.

While the benefits to the project are high, the investment presented itself as an opportunity to invest in core infrastructure that would not have been available otherwise.

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