



FRDC

FISHERIES RESEARCH &
DEVELOPMENT CORPORATION

FINAL REPORT

An Impact Assessment of Investment in FRDC Project 2017-109:

**Development of Fish Health Indicators for the Gladstone
Harbour Report Card**

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**An Impact Assessment of Investment in FRDC Project 2017-109: Development of Fish Health Indicators for the Gladstone Harbour Report Card
FRDC Project 2016-134**

2022

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- Nicole Flint, Principal Research Fellow, Sustainable Coastal Resources, Coastal Marine Ecosystems Research Centre, Gladstone

Abbreviations

CBA	Cost-Benefit Analysis
CQU	Central Queensland University
CRRDC	Council of Rural Research and Development Corporations
DAWR	Department of Agriculture and Water Resources
FRDC	Fisheries Research and Development Corporation
GHHP	Gladstone Healthy Harbour Partnership
GSI	gonadosomatic index
HAI	Health Assessment Index
HSI	hepatosomatic index
MIRR	Modified Internal Rate of Return
OCS	Office of the Chief Scientist
PVB	Present Value of Benefits
R&D	Research and Development
RD&E	Research, Development and Extension

Executive Summary

Water in port areas can be affected by a range of factors including shipping, portside industry, and runoff from a range of diverse sources and land uses surrounding the port. The Gladstone Healthy Harbour Partnership (GHHP) established a consortium to produce an annual report card on the health of the Gladstone Harbour. Fish health was one of the indicators identified for inclusion in the report card by an Independent Science Panel.

The health of fish in any given environment is an important biological indicator of environmental contamination. Further, several years before the project was funded, a number of fish deaths and fish with lesions had been reported in the Harbour, so an investigation of fish health in Gladstone Harbour was deemed to be required.

The primary objective of Fisheries Research and Development Project 2017-109 was to identify methods of monitoring fish health in Gladstone Harbour in Queensland. In addition, there was a wider objective of using the methods developed for monitoring fish health in other ports in northern Australia.

The primary output for the project was a research report and a Fish Health Indicator for the Gladstone Harbour Report Card for the GHHP. The intended primary beneficiaries of the research included commercial fishers, recreational fishers, seafood retailers and the general community around Gladstone and in northern Australia more generally.

The total funding for the fish health indicator project (2017-109) totalled \$270,705 in present value terms. Based on a quantitative analysis given various assumptions, the benefits from the investment were estimated to be \$746,795 in present value terms. This gave a net present value of \$476,090, a benefit-cost ratio of 2.76 to 1 and an internal rate of return of 25.3%.

As only one of a number of benefits identified was valued in the economic analysis, the investment criteria produced are likely to underestimate the overall performance of the investment. However, as explained later in this evaluation, the reasons that the other five impacts identified were not valued included one or more of the following: a lack of available or credible information on which to base assumptions, the value of the impact was likely to be small, and the impact identified was already indirectly included in the impact valued.

Introduction

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

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

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

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

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

Project 2017-109: *Fish Health Indicators for the Gladstone Harbour Report* was randomly selected as one of the 20 RD&E investments completed in 2019/20 for evaluation in the fifth series of annual impact assessments (2019/20 sample). The current report presents the Project 2017-109 analysis and findings.

Method

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

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

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

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

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

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

Project Background

Background

Fish are important biological indicators of environmental contamination. The water in port areas can be affected by a range of factors including shipping, portside industry, and runoff from a range of diverse sources and land uses. There is a range of fish health indicators available for use in northern Australian ports and estuaries. Following a series of fish deaths being reported over several years at Gladstone Harbour, as well some fish being caught that had lesions on them, the Gladstone Healthy Harbour Partnership (GHHP) established a consortium to produce an annual report card on the health of the Gladstone Harbour. Fish health was one of the indicators identified for inclusion in the report card by an Independent Science Panel.

Rationale for Project 2017-109

FRDC Project 2017-109 was based on a need for research to develop a fish sampling program and a set of fish health indicators for the region around Gladstone Harbour in Queensland. A number fish health indicators were reviewed with key indicators selected for use in the project. The primary output for the project was a research report and a Fish Health Indicator for the Gladstone Harbour Report Card for the GHHP. The intended primary beneficiaries of the research included commercial fishers, recreational fishers, seafood retailers and the general community around Gladstone and in northern Australia more generally. The new research was to build on previous studies undertaken by FRDC under the Aquatic Animal Health Subprogram

Project Details

Summary

Project Code: 2017-109
Title: <i>Fish Health Indicators for the Gladstone Harbour Report Card</i>
Research Organisation: Central Queensland University
Principal Investigators: Nicole Flint, Emma Jackson, Andrew Irving, Jeremy De Valck and Amie Anastasi, Central Queensland University (CQU)
Period of Funding: January 2018 to September 2018
FRDC Program Allocation: Environment 100%

Objectives

The objectives of the project were:

1. To review and identify suitable methods to monitor fish health in Gladstone Harbour.
2. To develop and implement a data collection approach to monitor fish health in Gladstone Harbour that is both cost-effective and suitable for a fish health indicator.
3. To evaluate the potential to adapt and transfer the methods and indicators developed to monitor fish health in other estuaries and ports in Northern Australia.
4. To develop fish health indicator(s) based on the data collected.

Logical Framework

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

Table 1: Logical Framework for FRDC Project 2017-109

Activities	<p><i>Indicator selection</i></p> <ul style="list-style-type: none">• Fish health indicators vary widely in cost and complexity; the indicators chosen for the Gladstone Harbour report card were those of low to medium cost and complexity.• Fish health indicators chosen for the pilot included external measurements, visual pathological changes, parasite counts, the application of an existing health assessment index, and histopathological analysis of tissue condition. <p><i>Species selection</i></p> <ul style="list-style-type: none">• Three fish taxa were initially targeted for the assessments including barramundi (<i>Lates calcarifer</i>), bream (<i>Acanthopagrus australis</i>) and large mullet (<i>Liza vaigiensis</i>); additional target species were added later, barred javelin (<i>Pomadasys kaakan</i>) and blue catfish (<i>Neoarius graeffei</i>).• The taxa were selected based on a range of criteria, with consideration given to recommendations made in previous work commissioned by GHHP, and to each species' relative mobility or how far they may travel (Nicole Flint, pers. comm., 2022).• For some of the fish species (unspecified), catch and recapture tagging data were provided by the SunTag program by InfoFish Australia to assess mobility. <p><i>Site selection</i></p>
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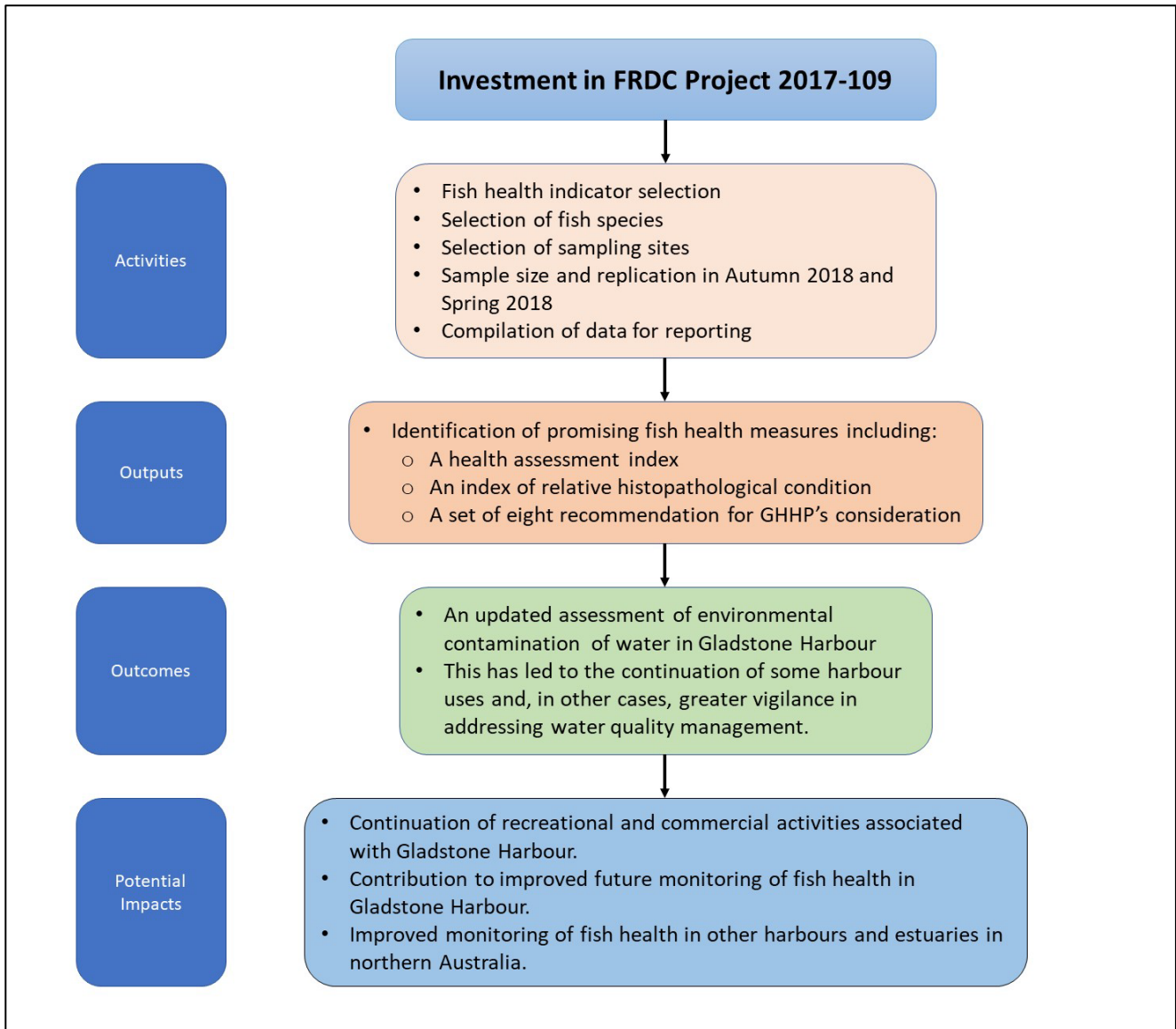
	<ul style="list-style-type: none"> • Sampling was undertaken at 12 Gladstone Harbour zones and two reference sites; the latter were selected based on geographical location, likely human impacts, accessibility, habitats suitable to the target species and their use in previous fish health studies. <p><i>Sample size and replication</i></p> <ul style="list-style-type: none"> • During Autumn 2018, 249 fish from 33 species were caught across the 12 zones and two reference sites; the species caught across the most sampling zones were barramundi (<i>L.calcarifer</i>), blue catfish (<i>N. graeffei</i>), blue threadfin (<i>Eleutheronema tetradactylum</i>, barred javelin (<i>P. kaakan</i>), diamond scale mullet (<i>L. vaigiensi</i>) and giant queenfish (<i>Scomberoides commersonianus</i>). • During Spring 2018, 291 fish from 33 species were caught across the 12 zones and two reference sites; the species caught across the most sampling zones were barred javelin, blue catfish (<i>N. graeffei</i>), diamond scale mullet (<i>L.vaigiensi</i>), blue threadfin (<i>E.tetradactylum</i>), barramundi (<i>L. calcarifer</i>), and sea mullet (<i>Mugil cephalus</i>). <p><i>Compilation of data for reporting purposes</i></p> <ul style="list-style-type: none"> • All fish were measured, weighed, checked for abnormalities and released; some target species were humanely killed for further laboratory analysis of the identified fish health indicators.
Outputs	<ul style="list-style-type: none"> • Several new preliminary fish health measures that appeared promising were identified, including two that were particularly promising: <ul style="list-style-type: none"> ○ A health assessment index (HAI); this produces a score based on the condition of several organs and tissues; individual fish scores can be averaged to give a total HAI for each species, and for the harbour. ○ An index of relative histopathological condition that required further testing. • A set of recommendations for GHHP’s consideration emanated from the project, the recommendations were: <ol style="list-style-type: none"> 1. HAI continue to be monitored (funded by GHHP in subsequent years), but histopathology was considered too expensive for ongoing monitoring (Nicole Flint, pers. comm., 2022). 2. GHHP considered whether to provide a wider range of fish tissues for histopathological analysis; such analyses were not continued, but tissues have been retained and stored for future histopathological analysis if funding becomes available (Nicole Flint, pers. comm., 2022) 3. GHHP continues to monitor Fulton’s K an (index estimate of body condition determined by measuring the weight and length of individual fish), HSI (a hepatosomatic index measured as a ratio of liver weight to body weight), GSI (a gonadosomatic index measured as a ratio of gonad weight to body weight) and fluctuating asymmetry of eye diameter; such monitoring would increase the comprehensiveness of fish health assessments. 4. GHHP have continued to record these parameters in subsequent sampling rounds funded by GHHP, except for fluctuating asymmetry of eye diameter. The latter is the topic of a Master’s Degree by Research Project. currently underway at CQ University (Nicole Flint, pers. comm., 2022). 5. GHHP considered testing for bioaccumulation of metals and other toxicants in collected fish tissue samples, but this was not actioned. 6. GHHP considered a hook and line fishing component in 2019 to capture more bream, but this activity was not actioned (Nicole Flint, pers. comm., 2022).

	<p>7. GHHP considered adding barred javelin and blue catfish as target species in 2019; this recommendation was accepted and both species were monitored in subsequent sampling rounds funded by GHHP.</p> <p>8. GHHP considered targeting fish sampling at a reduced number of zones in Gladstone Harbour; this was accepted and sampling was subsequently undertaken at a harbour-wide scale instead of in every zone (Nicole Flint, pers. comm., 2022).</p> <p>9. GHHP considered continuing to sample at reference points at least once a year; however, this ceased in a subsequent round of sampling for GHHP (post the FRDC funded project) (Nicole Flint, pers. comm., 2022).</p>
Outcomes	<ul style="list-style-type: none"> • The Gladstone Harbour Report Card assessment was updated to include fish health indicators as measures of environmental contamination and water health; this updated assessment of the extent of environmental contamination of water in Gladstone Harbour has allowed various stakeholders to continue safely with current policies/activities, or in some cases to be more vigilant in their care and management of water quality in Gladstone Harbour. Specific beneficiaries may include: <ul style="list-style-type: none"> ○ Commercial and recreational fishers, ○ Seafood retailers, and ○ The general community, including those responsible for regulating runoff and discharges into the Harbour. • Objective 3 of the project was achieved, that is, the evaluation of the potential to adapt and transfer the methods and indicators developed to monitor fish health in other estuaries and ports in Northern Australia.
Impacts	<p>Potential impacts of Project 2017-109 include:</p> <ul style="list-style-type: none"> • Continuation of recreational and commercial activities associated with Gladstone Harbour. • Contribution to improved future monitoring of fish health in Gladstone Harbour. • Potential for improved monitoring of fish health in other harbours and estuaries in northern Australia. • Potential continued/ improved social amenity of the Gladstone Harbour.

Pathway to Impact

A diagram describing the simplified pathways to impact for the investment in Project 2017-109 is provided in Figure 1.

Figure 1: Pathway to Impact for Project 2017-109



Nominal Investment

Table 2 shows the annual investment made in Project 2017-109 by FRDC, GHHP and CQU.

Table 2: Agreed Annual Investment in Project 2017-109 (nominal \$)

Year ended 30 June	FRDC (\$)	GHHP^(a) (\$)	CQU (\$)	TOTAL (\$)
2018	32,235	20,000	4,747	56,982
2019	104,066	20,000	15,323	139,389
Total	136,301	40,000	20,070	196,371

(a) Nicole Flint commented that GHHP also contributed funding to CQU

Source: Financial Acquittal documentation and Nicole Flint

Program Management Costs

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

Real Investment and Extension Costs

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

Impacts

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

Table 3: Triple Bottom Line Categories of Principal Impacts from Project 2017-109

Economic	<ul style="list-style-type: none"> • Reduction in potential economic loss via shipping transport and a diversity of industries in Gladstone Harbour. • Reduction in potential loss of value of recreational assets in Gladstone Harbour.
Environmental	<ul style="list-style-type: none"> • Reduction in potential loss of value of environmental assets in Gladstone Harbour.
Social	<ul style="list-style-type: none"> • Improved monitoring of fish health in other harbours and estuaries in northern Australia. • Enhanced capacity and capability of Australian scientists involved in fish health monitoring. • Positive impacts on Gladstone Harbour regional communities influenced by economic loss of shipping and harbour industries. • Potential continued/ improved social amenity of the Gladstone Harbour.

Public versus Private Impacts

The principal private impacts identified in this evaluation are directly related to the potentially reduced risk of future economic impacts on shipping and industry assets in Gladstone Harbour. The public impacts include a potentially reduced risk of damage to environmental and recreational assets in the Harbour, positive spillovers to regional communities, an enhancement of scientific capacity, continued/improved social amenity of the Gladstone Harbour and improved monitoring in other estuaries and harbours in northern Australia.

Distribution of Private Impacts

The benefits from reduced economic losses and any additional costs will directly accrue to Gladstone Harbour businesses. Such private benefits likely will be shared by members of the various associated supply chains according to associated supply and demand elasticities.

Impacts on Other Australian Industries

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

Impacts Overseas

It is unlikely for there to be any major impacts outside of Australia. The significant international trade with other countries that is conducted via the Gladstone Harbour is unlikely to be affected.

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 2017-109 indirectly contributed to National Science and Research Priorities 1 and 2. Further, the RD&E investment may contribute indirectly to Agricultural Innovation Priorities 2 and 3 through improved monitoring of fish health in the Gladstone Harbour.

Table 4: Australian R&D Priorities

Australian Government	
National Science and Research Priorities¹	National Agricultural Innovation Priorities²
<ol style="list-style-type: none"> 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. 	<p>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.</p> <ol style="list-style-type: none"> 1. Australia is a trusted exporter of premium food and agricultural products by 2030. 2. Australia will champion climate resilience to increase the productivity, profitability, and sustainability of the agricultural sector by 2030. 3. Australia is a world leader in preventing and rapidly responding to significant incursions of pests and diseases through futureproofing our biosecurity system by 2030. 4. Australia is a mature adopter, developer, and exporter of digital agriculture by 2030.

FRDC National RD&E Priorities

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

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

Project 2017-109 addressed FRDC national RD&E priority 1 by building capability and capacity and improving fish health monitoring and reporting for the Gladstone Harbour.

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

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

Valuation of Impacts

Impact Valued

A single impact was valued in the assessment of FRDC Project 2017-109. The impact valued is a reduced risk of a small fall in one of the community recreational values of Gladstone Harbour, that is, the value of recreational fishing. For purposes of the valuation, It is assumed that the fall in values is related to the perception of fish health in the Harbour.

Other recreational values of the harbour potentially could also be reduced by a decline in fish health, such as land-based recreation (walking, picnicking, and relaxing by the water), but any such decline in such other recreational amenities was less direct and not valued in this assessment.

Specific assumptions made for the valuation of the impact are provided in Table 6. A number of the assumptions involved some uncertainty, so that some degree of conservatism was effected when finalising the assumptions for valuing the impact.

Impacts Not Valued

The impacts identified in Table 3 but not valued included:

- Reduction in potential economic loss via shipping transport and a diversity of industries in Gladstone Harbour.
- Reduction in potential loss of value of environmental assets in Gladstone Harbour.
- Improved monitoring of fish health in other harbours and estuaries in northern Australia.
- Enhanced capacity and capability of Australian scientists involved in fish health monitoring.
- Positive impact on Gladstone Harbour regional communities influenced by a reduction in economic loss of recreational fishing and shipping and harbour industries.

The five impacts identified in Table 3 were not valued for the following reasons (Table 5):

Table 5: Reasons for Not Valuing Impacts

Impact/Potential Impact	Reason why Impact Not Valued
Reduction in potential economic loss via shipping transport and a diversity of industries in Gladstone Harbour.	This impact has been assumed to be associated with a minimal risk compared to recreational fishing.
Reduction in potential loss of value of environmental assets in Gladstone Harbour.	This impact is already valued indirectly through the reduced risk of a fall in one of the community recreational values of Gladstone Harbour, the value of recreational fishing.
Improved monitoring of fish health in other harbours and estuaries in northern Australia.	The likely improvement in fish health in other northern Australia harbours was not valued due to lack of specific data being available and the constrained resources available to the assessment.
Enhanced capacity and capability of Australian scientists involved in fish health monitoring.	Credible information was not readily available on which to base any assumptions to value any enhanced capacity.
Positive impact on Gladstone Harbour regional communities influenced by potential economic loss of recreational fishing and shipping and harbour industries.	This impact has not been valued due to a lack of available and credible information on which to base assumptions.

Summary of Assumptions

Table 6 shows the specific assumptions used in the valuation of impacts.

Table 6: Summary of Assumptions

Variable	Assumption	Source
Total recreational fishing trip value for Gladstone Harbour	\$31.19 million per annum	Economic Indicators (GHHP, 2014-2022)
Potential fall in recreational fishing value per annum due to fish health perceptions	10%	Agtrans Research
Reduction in risk due to findings from Project 2017-109		
Risk of fall in recreational fishing trip value over next five years for Gladstone Harbour without project	10%	Analyst assumptions
Risk of fall in recreational fishing trip value over next five years for Gladstone Harbour with project	9% (that is, a decrease in risk of 1%)	
First year of risk reduction due to investment	2021	
Final year of risk reduction due to investment	2030	Analyst assumption based on the potential for other water quality improvements being implemented in the meantime
Risk factors and counterfactual		
Probability of output	100%	Analyst assumptions
Probability of outcomes occurring	75%	
Probability of impacts occurring given successful outcome	75%	
Counterfactual	Impacts assumed would not have occurred without the project	

Results

All benefits were expressed in 2020/21 dollar terms. All costs and benefits were discounted to 2021/22 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2018/19) to the final year of benefits assumed.

Investment Criteria

Tables 7 and 8 show the investment criteria estimated for different periods of benefits for the total investment and FRDC investment respectively.

Table 7: Investment Criteria for Total Investment in Project 2017-109

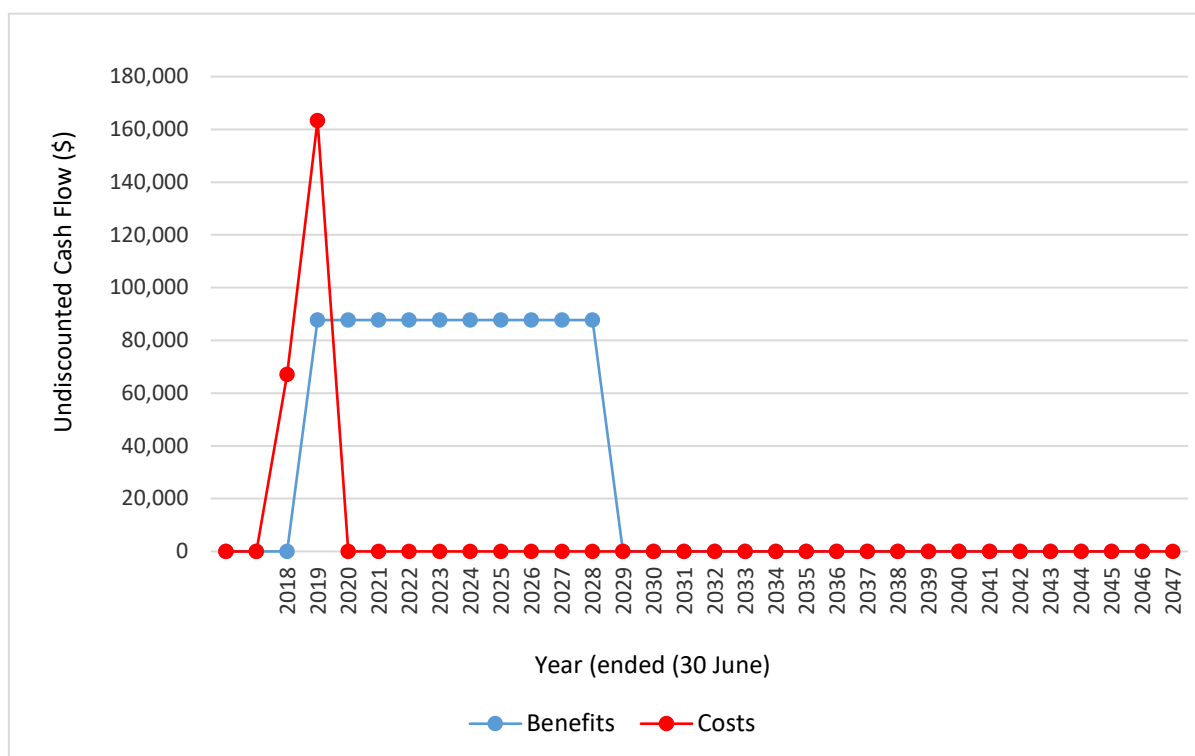
Investment criteria	Number of years from year of last investment						
	0	5	10	15	20	25	30
Present value of benefits (\$m)	0	342,941	687,421	746,795	746,795	746,795	746,795
Present value of costs (\$m)	270,705	270,705	270,705	270,705	270,705	270,705	270,705
Net present value (\$m)	-270,705	72,236	416,716	476,090	476,090	476,090	476,090
Benefit-cost ratio	0.00	1.27	2.54	2.76	2.76	2.76	2.76
Internal rate of return (%)	negative	11.9	24.6	25.3	25.3	25.3	25.3
MIRR (%)	negative	18.2	20.0	14.3	11.5	10.0	9.0

Table 8: Investment Criteria for FRDC Investment in Project 2017-109

Investment criteria	Number of years from year of last investment						
	0	5	10	15	20	25	30
Present value of benefits (\$m)	0	249,226	499,570	542,719	542,719	542,719	542,719
Present value of costs (\$m)	196,259	196,259	196,259	196,259	196,259	196,259	196,259
Net present value (\$m)	-196,259	52,966	303,311	346,459	346,459	346,459	346,459
Benefit-cost ratio	0.00	1.27	2.55	2.77	2.77	2.77	2.77
Internal rate of return (%)	negative	12.1	24.9	25.6	25.6	25.6	25.6
MIRR (%)	negative	18.3	20.0	14.3	11.5	10.0	9.0

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

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



Sensitivity Analyses

A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table 9 presents the results. The results showed a moderate sensitivity to the discount rate, largely due to the benefit period assumed to commence very soon after the project was completed.

Table 9: Sensitivity to Discount Rate

Investment Criteria	Discount Rate		
	0%	5% (base)	10%
Present value of benefits (\$)	877,219	746,795	652,206
Present value of costs (\$)	230,490	270,705	315,714
Net present value (\$)	646,729	476,090	336,492
Benefit-cost ratio	3.81	2.76	2.07

A sensitivity analysis was undertaken also on the assumed extent of the potential fall in recreational fishing trip value in future, with and without the project. Results are shown in Table 10. For the project investment to just break even, there would need to be a 3.6% fall in the fishing trip value in future, given no changes in all other assumptions.

Table 10: Sensitivity to Assumption of Fall in Fishing Trip Value in Future

Investment Criteria	Assumed Potential Fall in Fishing Trip Value in Future		
	5%	10% (base)	15%
Present value of benefits (\$)	373,397	746,795	1,120,192
Present value of costs (\$)	270,705	262,215	270,705
Net present value (\$)	102,692	484,580	849,487
Benefit-cost ratio	1.38	2.85	4.14

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 11). 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 11: Confidence in Analysis of Project

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

The coverage of benefits was assessed as Medium-Low. Of the six impacts identified in Table 3, only one was valued. The reasons for non-valuation of the other five impacts are provided in Table 5, including minimal risk change in economic loss in the transport and industry sector and an overlap of any environmental loss with the impact valued; a lack of availability of credible information was the main reason the other three impacts identified were not valued. For the impact valued, many of the assumptions used were realistic but the critical assumption of the probability shift of a fall in recreational fishing trip value with and without the project was necessarily subjective. Hence, the overall rating of confidence in the assumptions was considered Medium-Low.

Conclusions

The assessment of the investment in FRDC Project 2017-109 found that Gladstone Harbour and its associated communities have gained significantly by the generation of new information on fish health in Gladstone Harbour.

Funding for this fish health project over the two years totalled \$270,705 (present value terms). The single impact was valued at \$746,795 (present value terms). This gave a net present value of \$476,090, a benefit-cost ratio of 2.76 to 1, an internal rate of return of 25.3% and a modified internal rate of return of 9.0%.

The set of investment criteria estimated are uncertain due to the lack of strong evidence supporting the assumptions associated with the single impact valued. However, as a number of other potential impacts were identified but not valued in monetary terms, the investment criteria as provided by the valued benefit are still likely to be an underestimate of the total value of the project investment.

Glossary of Economic Terms

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

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