



FRDC

FISHERIES RESEARCH &
DEVELOPMENT CORPORATION

FINAL

**An Impact Assessment of FRDC
Investment in 2014-204:
Implications of current spatial
management measures for AFMA
ERAs for habitats**

Agtrans Research

August 2018

FRDC Project No 2016-134

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Project 2016-134**

2018

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The Fisheries Research and Development Corporation plans, invests in and manages fisheries research and development throughout Australia. It is a statutory authority within the portfolio of the federal Minister for Agriculture, Fisheries and Forestry, jointly funded by the Australian Government and the fishing industry.

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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.

Roland Pitcher, Senior Principal Research Scientist, CSIRO Oceans and Atmosphere

Abbreviations

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
AFMA	Australian Fisheries Management Authority
CBA	Cost-Benefit Analysis
CMR	Commonwealth Marine Reserve
CRRDC	Council of Rural Research and Development Corporations
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWR	Department of Agriculture and Water Resources (Commonwealth)
ERA	Ecological Risk Assessment
ERAEF	Ecological Risk Assessment for the Effects of Fishing
ERM	Ecological Risk Management
FRDC	Fisheries Research and Development Corporation
GVP	Gross Value of Production
MIRR	Modified Internal Rate of Return
OCS	Office of the Chief Scientist
PVB	Present Value of Benefits
RD&E	Research, Development and Extension

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 *implications of current spatial management measures for AFMA ERAs for habitats*. The project was funded by FRDC over the period July 2014 to December 2015.

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 impacts identified were of a financial and social nature involving increased efficiency of resource allocation with respect to the Australian Fisheries Management Authority (AFMA) Ecological Risk Assessments (ERAs) and enhanced social licence to operate for Commonwealth trawl fisheries. The investment has likely contributed to improved prioritisation and data/knowledge gap identification for habitat ERAs under AFMA's Ecological Risk Management framework.

Investment Criteria

Total funding from all sources for the project was \$0.41 million (present value terms). FRDC investment in the project totalled \$0.25 million. The total investment produced estimated total expected benefits of \$0.70 million (present value terms). This gave a net present value of \$0.29 million, an estimated benefit-cost ratio of 1.7 to 1, an internal rate of return of 19.6% and a modified internal rate of return of 6.9%.

Conclusions

The investment in this project group has provided trawl exposure and protection assessment information using an assemblage method for Commonwealth trawl fisheries that is likely to have provided AFMA with valuable information that may be used to identify priorities and/or gaps regarding the need for future habitat ERAs.

While some environmental and social impacts identified were not valued, these impacts were considered minor when 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, ecological risk assessment, ERA, Commonwealth fisheries, seabed assemblages mapping, trawl footprint

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 2014-204: *Implications of current spatial management measures for AFMA ERAs for habitats* 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

Background

AFMA and Ecologically Sustainable Development

The Australian Fisheries Management Authority (AFMA) manages and monitors commercial Commonwealth fishing to ensure Australian fish stocks, and the Australian fishing industry, are viable now and into the future (AFMA, n.d.(a)).

AFMA is governed by several key pieces of legislation including the *Fisheries Administration Act 1991*, the *Fisheries Management Act 1991*, the *Torres Strait Fisheries Act 1984*, and the *Environment Protection and Biodiversity Conservation Act 1999*. Three of the four governing Acts require AFMA to pursue Ecologically Sustainable Development (AFMA, n.d.(b)).

As part of its commitment to an ecosystem-based approach to fisheries management, AFMA has developed an Ecological Risk Management (ERM) framework that assists decision makers in developing fisheries policy, regulations and management arrangements. The framework uses an Ecological Risk Assessment for the Effects of Fishing (ERAEF) as the primary means of assessing the risks a fishery poses to the marine ecosystem (AFMA, 2017a).

Ecological Risk Assessments (ERAs)

The ERAEF involves a hierarchy of risk assessment methodologies progression from a qualitative analysis to a more detailed and quantitative analysis. The approach allows for identification of high and low risk species, as well as those that are data deficient. The ERAEF considers the impacts of fishing on five key components of the marine environment: commercial species, by-product species, bycatch species, protected species, and habitats and communities.

In the past, fisheries managers have concentrated on target species and used measures such as population size and maximum sustainable yield estimates to manage fisheries. The ERAEF, on the other hand, considers risks to all ecosystem components affected by a fishery and allows identification of which species, habitats and communities are at risk from the effects of fishing.

ERAEF provides AFMA with a basis for the development of Fishery Management Strategies for each Commonwealth fishery that includes (AFMA, 2017a):

- fishery specific harvest strategies,
- fishery specific ERM,
- fishery specific Bycatch and Discard Action Plans, and
- 5-year Research Strategies.

Commonwealth Fisheries and Trawl Fishing

The gross value of production (GVP) for Commonwealth Fisheries was estimated at \$438.8 million in 2015/16 (ABARES, 2017).

Trawling is one of the most frequently used methods of commercial fishing. Trawl nets are designed to be towed, by a boat, through the water column (midwater trawl) or along the sea floor (bottom trawl).

Bottom trawls (demersal trawls) are used to catch fish and prawns that live on or near the sea floor. The main species targeted by demersal trawl in Australia are: flathead, pink ling, blue grenadier, silver warehou, and prawns.

Table 1 lists the various Commonwealth fisheries and fishery zones managed by AFMA and includes information as to whether trawl fishing is used as a commercial fishing method at each fishery.

Table 1: Commonwealth Fisheries Managed by AFMA

No.	AFMA Commonwealth Fishery	Trawl Fishing Used	Fishery Value (\$m)
1.	Bass Strait Central Zone Scallop Fishery	No ^(a)	2.8
2.	Christmas Island and Cocos Islands	Unknown	Not available
3.	Convention for the Conservation of Antarctic Marine Living Resources New and Exploratory Fisheries	No	Confidential
4.	Coral Sea Fishery	Yes	Confidential
5.	Eastern Tuna and Billfish Fishery	No	48.8
6.	Heard Island and McDonald Islands Fishery	Yes	Confidential
7.	Macquarie Island Toothfish Fishery	No	Confidential
8.	High Seas Permits	Yes ^(b)	Not available
9.	Norfolk Island Fishery ^(c)	n/a	n/a
10.	North West Slope Trawl Fishery	Yes	Confidential
11.	Northern Prawn Fishery	Yes	124.0
12.	Skipjack Tuna Fishery	No	Not available
13.	Small Pelagic Fishery	Yes ^(d)	Confidential
14.	Southern and Eastern Scalefish and Shark Fishery	Yes ^(e)	73.0
15.	Southern Bluefin Tuna Fishery	No	35.9
16.	Southern Squid Jig Fishery	No	0.9
17.	South Tasman Rise ^(f)	n/a	n/a
18.	Protected Zone Joint Authority (Torres Strait Fisheries)	Yes ^(g)	24.4
19.	Western Deepwater Trawl Fishery	Yes	Confidential
20.	Western Tuna and Billfish Fishery	No	Confidential
Total Value of Commonwealth Fisheries (2015/16)			438.8

Source: AFMA: <http://www.afma.gov.au/fisheries/>; ABARES, 2017

n/a: not applicable

- (a) Towed scallop harvester (dredge) used to collect scallops from sea floor. Can be considered a type of trawl gear.
- (b) Includes the South Pacific Regional Fisheries Management Organisation area.
- (c) Information not available. There is currently no commercial fishing activity in the Norfolk Island Fishery (as at June 2018: <http://www.afma.gov.au/fisheries/norfolk-island-fishery/>).
- (d) Midwater trawl only.
- (e) Commonwealth Trawl Sector and Great Australian Bight Trawl Fishery only.
- (f) Though trawl fishing is permitted under certain conditions, the South Tasman Rise Sector has been closed since 2007 (as at June 2018: <http://www.afma.gov.au/fisheries/south-tasman-rise/>).
- (g) Some of the Torres Strait Fisheries permit trawl fishing (e.g. Torres Strait Prawn Trawl Fishery).

Rationale

ERAs for Australian fisheries have largely focussed on bycatch and by-product species with ERM responses focused on species assessed as being at high risk. ERAs for bycatch species have been conducted for most Commonwealth fisheries; however, research has demonstrated that towed demersal fishing gear can impact seabed habitats and communities, that consequently may be at risk. Accordingly, ERAs for habitats have been completed at a qualitative level for some Commonwealth fisheries but, as a result of inadequate data for most fisheries, most habitat ERAs were non-spatial (i.e. the spatial extent and overall magnitude of risk were unknown) and interim in nature.

In recent years, new data and methods have become available that allow more advanced ERAs. Further, various new management measures have been implemented in some fisheries, such as effort management and fishery closures, that may have changed the spatial extent of potential risk to habitats from trawling.

Thus, AFMA identified a need to extend the ERAs covering habitats, and to take into account the recent management. Specifically, AFMA's stated priority was a gap analysis to determine the extent to which individual fishery ERAs, and hence ERM, need to address habitats considering other fishery management measures now in place and following the finalisation of the Commonwealth Marine Reserve (CMR) network. Project 2014-024 was funded to address this priority, utilising new data and spatial mapping methods, for all Commonwealth demersal fisheries that use towed bottom-contact gear (trawls, dredges) in Australian continental shelf and slope waters.

Project Details

Summary

Project Code: 2014-204

Title: *Implications of current spatial management measures for AFMA ERAs for habitats*

Research Organisation: CSIRO

Principal Investigator: Roland Pitcher

Period of Funding: July 2014 to December 2015

FRDC Program Allocation: Environment (100%)

Objectives

The project's key objectives were to capitalise on recently collated data and mapped distributions of predicted demersal assemblages and associated habitats – as well as data for Commonwealth demersal fishing effort, fishery closures and marine reserves – to provide:

1. quantification of the overlap of fishing effort and intensity with each mapped assemblage/habitat,
2. quantification of the overlap of each mapped assemblage/habitat with areas of spatial management that exclude fishing, such as closures and reserves,
3. a gap analysis and prioritisation of which mapped assemblages/habitats, and in which fisheries, may require future focus for AFMA's fishery ERAs,
4. qualitative assessment of the potential risk implications for any habitat forming biota (if/where data available) in assemblages with high exposure to fisheries, given current spatial management.

Logical Framework

Project 2014-204 aimed to quantify the overlap of mapped seabed assemblages with trawl footprints, and with areas of spatial management that exclude trawling, by building on previously collated data and assemblage mapping as well as data for Commonwealth demersal trawling effort, fishery closures and marine services. Table 2 provides a more detailed description of the project in a logical framework.

Table 2: Logical Framework for Project 2014-203

Activities and Outputs	<ul style="list-style-type: none">• Seven fisheries were assessed during the course of the project. Each fishery was analysed separately within its respective management jurisdiction boundary subject to a maximum depth of 1,500 metres for fish trawl fisheries and 150 metres for prawn and scallop fisheries.• Fisheries assessed included:<ul style="list-style-type: none">○ the Southeast Commonwealth Trawl Sector○ the Bass Strait Central Zone Scallop (dredge) Fishery○ the Great Australian Bight Trawl Fishery○ the Western Deepwater Trawl Fishery○ the Northwest Slope Trawl Fishery○ the Northern Prawn Fishery○ the Torres Strait Prawn Fishery.• Most Commonwealth fisheries lack data for seabed habitats. Therefore, assemblages were defined based on quantification of bio-physical relationships and used as surrogates for habitats at an intermediate scale.• Each assemblage represented an area having similar environmental conditions and expected to have a similar mix of fish and invertebrate species.
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	<ul style="list-style-type: none"> • Biological survey datasets and environmental layers were collated, as well as data for trawl effort distribution and intensity, and for fishery closures, CMRs and other Marine Protected Areas. • Multiple biological survey datasets were then analysed with the environmental layers to quantify the magnitude of change in demersal species composition along the environmental gradients. • Information from the analysis then was used to predict and map the distribution of demersal assemblages on a 0.01° grid. • Trawled-area footprints were estimated from logbook or Vessel Monitoring System effort data for a three-to-five year period post-2007 (after significant restructuring had been implemented in several Commonwealth fisheries) and also mapped on the 0.01° grid along with fishery closures and CMRs. • The overlap of each assemblage with trawling and closed areas was then quantified by area and as a percentage. • All CMRs were assumed to exclude trawling. • The research provided, for all Commonwealth demersal trawl fisheries, a consistent spatial approach for mapping seabed assemblages and assessing exposure and protection of the demersal environment in lieu of habitat data for most fisheries. • The project found that the majority of the 106 seabed assemblages defined and mapped had little or no exposure to trawling by the Commonwealth trawl fisheries assessed. • These assemblages with low trawl exposure included a large number with little or no protection in closed areas, in addition to those with high levels of protection in closures. • Across all fisheries there were relatively few assemblages that had both high exposure to trawling and low protection by closed areas. • Several highly exposed assemblages also had substantial inclusion in closed areas. For example, five assemblages had >20% annual trawl footprint exposure, of which two had >20% protection in areas closed to trawling. • The majority of demersal assemblages within the Commonwealth trawl fishery jurisdictions are not likely to be subject to substantive risk from these fisheries. This is primarily because of their low exposure and is largely independent of whether the assemblages had high or no protection. • The project recommended that assemblages with both high exposure and low protection should be flagged as a higher priority for future AFMA habitat ERAs to assess whether vulnerable habitats are present and whether they are at risk from demersal trawl or dredge fishing. • The project recommended that additional research be undertaken to map assemblages that fell outside the Commonwealth trawl and dredge fishery jurisdictions assessed within the project scope. • The co-Principal Investigators for the project participated in a Forum of the Expert Scientific Panel for the Commonwealth Marine Reserve Review in June of 2015 and presented the preliminary results of the project. • Further extension included presentations at various Resource Assessment Group meetings and information on the impact of trawl fishing on Australian fisheries was included in the 2016 State of the Environment report (see: https://soe.environment.gov.au/theme/marine-environment/topic/2016/commercial-and-recreational-fishing#marine-environment-box-2). The information also included a case-study on the footprint of trawl fishing (see: http://catalogue.aodn.org.au/geonetwork/srv/eng/metadata.show?uuid=4a7d21a0-84d2-40e4-9d8a-5f3f21fafa10) (Roland Pitcher, pers. comm., 2018).
Outcomes	<ul style="list-style-type: none"> • The trawl exposure and protection assessments have provided information that AFMA may use as an input to identify priorities and/or gaps, regarding the need for any future habitat ERAs for Commonwealth fisheries.

	<ul style="list-style-type: none"> • This improved focus/prioritisation will assist with a more efficient application of AFMA resources with regard to management expenditure on ERAs for habitats. • Further research was funded to extend the methods applied to other fishery jurisdictions (FRDC project 2016-039) (Roland Pitcher, pers. comm., 2018).
Impacts	<ul style="list-style-type: none"> • Potentially, more efficient AFMA ERA expenditure because of improved prioritisation of future habitat ERAs for Commonwealth trawl fisheries. • Potentially, improved environmental sustainability of Commonwealth trawl fisheries as a result of management practice changes in or around high risk marine habitats because of improved habitat ERA prioritisation. • Potentially, some contribution to enhanced social licence to operate for Australian trawl fisheries from improved environmental sustainability of Commonwealth trawl fisheries (Roland Pitcher, pers. comm., 2018). • Increased scientific knowledge and research capacity.

Project Investment

Nominal Investment

Table 3 shows the annual investment (cash and in-kind) in project 2014-204 by FRDC and others. ‘Other’ investors included CSIRO only.

Table 3: Annual Investment in the Project 2014-204 (nominal \$)

Year ended 30 June	FRDC (\$)	OTHER (\$)	TOTAL (\$)
2015	119,986	121,785	241,771
2016	71,304	4,639	75,943
Totals	191,290	126,424	317,714

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, Annual Reports, 2013-2017). This multiplier then was applied to the nominal investment by FRDC shown in Table 3.

For the CSIRO investment (other), it was assumed that program management and administration costs were already included in the nominal amounts shown in Table 3.

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 consultation with key stakeholders, including AFMA and other fisheries managers, and relevant extension of project outputs through presentations and published project findings.

Impacts

Table 4 provides a summary of the principal types of impacts from project 2014-204 investment. Impacts have been categorised into economic, environmental and social impacts.

Table 4: Triple Bottom Line Categories of Principal Impacts from Project 2014-204

Economic	<ul style="list-style-type: none"> • Potentially, more efficient AFMA ERA expenditure because of improved prioritisation of future habitat ERAs for Commonwealth trawl fisheries.
Environmental	<ul style="list-style-type: none"> • Potentially, improved environmental sustainability of Commonwealth trawl fisheries as a result of management practice changes in or around high risk marine habitats because of improved habitat ERA prioritisation.
Social	<ul style="list-style-type: none"> • Potentially, some contribution to enhanced social licence to operate for Australian trawl fisheries from improved environmental sustainability of Commonwealth trawl fisheries (Roland Pitcher, pers. comm., 2018). • Increased scientific knowledge and research capacity.

Public versus Private Impacts

The impacts identified for project 2014-204 are predominantly public impacts. Public impacts are likely to be delivered through more efficient allocation of AFMA resources for ERAs, improved environmental sustainability and increased scientific research capacity. Some minor private impacts may be realised should industry use the research outputs (e.g. assemblage method) to improve the efficiency of industry level risk assessments, or where improved prioritisation of AFMA ERAs leads to enhanced social licence to operate within Commonwealth trawl fisheries.

Distribution of Private Impacts

Private impacts from the project are likely to be minor. However, any private impacts would primarily be captured by individual commercial fisheries operating in Australia. Impacts would be distributed according to associated supply and demand elasticities along the fisheries' supply chains.

Impacts on other Australian industries

It was assumed that any minor private impacts from the investment in project 2014-204 will be confined to Australian wild-catch trawl fisheries and their associated supply chains.

Impacts Overseas

No significant impacts to overseas parties are expected. However, the approach used in project 2014-204 has been noted and viewed positively by international researchers and may be taken up by overseas fisheries agencies in the future (Roland Pitcher, pers. comm., 2018).

Match with National Priorities

The Australian Government’s Science and Research Priorities and Rural RD&E priorities are reproduced in Table 5. The project findings and related impacts will contribute primarily to Rural RD&E Priority 3, and to Science and Research Priority 1.

Table 5: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities (est. 2015)	Science and Research Priorities (est. 2015)
<ol style="list-style-type: none"> 1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D 	<ol style="list-style-type: none"> 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.

Two impacts of the project were valued:

1. The direct, potential economic impact of more efficient AFMA ERA resource allocation through improved prioritisation of future habitat ERAs for Commonwealth trawl fisheries, and
2. The indirect, potential social impact of enhanced social licence to operate for Australian trawl fisheries as a result of improved future environmental sustainability.

Impacts Not Valued

Not all impacts identified in Table 4 could be valued in the assessment. Social and environmental impacts were hard to value because of a lack of evidence/data, difficulty in quantifying the causal relationships and pathways between the project 2014-204 investment and the impacts, and the complexity of assigning monetary values to the social and environmental impacts.

The environmental impact identified but not valued included:

- Potentially, improved environmental sustainability of Commonwealth trawl fisheries as a result of management practice changes in or around high risk marine habitats because of improved habitat ERA prioritisation.

The social impacts identified but not valued included:

- Increased scientific knowledge and research capacity.

Valuation of Impact 1: Increased Efficiency of AFMA ERA Resource Allocation

The valuation of increased efficiency of AFMA ERA resource allocation centres on the estimated average annual investment in ERAs conducted by AFMA. Total expense costs for AFMA were approximately \$31.0 million in 2016/17 (AFMA, 2017b). Expenditure on research was reported at \$3.89 million for the same year, approximately 12.5% of total AFMA expenses.

The assemblage methods used by project 2014-204 and the trawl exposure and protection assessments completed provided information to AFMA that is likely to be used to identify priorities and/or knowledge/data gaps associated with the need for any future habitat ERAs for Commonwealth fisheries.

It was assumed that AFMA is using the project outputs to make improved ERA funding decisions that will result in a more efficient allocation of AFMA resources with regard to expenditure on ERAs for marine habitats. It was also assumed that the use of the project outputs will provide a 2.5% resource efficiency gain to AFMA ERA expenditure that was estimated to be 1.0% of AFMA's total expense costs for 2016/17 (\$0.31m). The full impact was assumed to apply for five years following completion of project 2014-204, declining linearly to zero thereafter as new methods and information for ERAs become available.

Specific assumptions for valuing Impact 1 are provided in Table 6.

Valuation of Impact 2: Enhanced Social Licence for Commonwealth Trawl Fisheries

The methods and information generated by project 2014-204 are likely to improve the prioritisation of habitat ERAs. This improved prioritisation will contribute to AFMA's ERM framework that assists decision makers in developing policy, regulations and management arrangements for Commonwealth fisheries. Improved decision making under the ERM framework, in turn, supports AFMA's pursuit of Ecologically Sustainable Development for Commonwealth Fisheries.

Potential improvements to the environmental sustainability of Commonwealth trawl fisheries that occurs because of information produced by AFMA's improved ERA prioritisation and processes may enhance the social licence to operate for Australia's numerous trawl fisheries, as there may be less opposition to certain fisheries/gear use.

It was assumed that 50% of the gross value of Commonwealth fisheries represent trawl fisheries and are at risk of some form of loss of social licence. The risk was assessed as a 10% reduction in the profitability of these fisheries without the project 2014-204 investment. Given the availability of the project outputs, it was assumed that the risk may fall slightly from 10% to a 9.5% reduction in the profitability for the applicable trawl fisheries. The impact was assumed to last for 5 years from the release of the 2014-204 findings, declining linearly to zero thereafter.

Specific assumptions for valuing Impact 2 are provided in Table 6.

Counterfactual

It was assumed that, if project 2014-204 had not been funded, the benefits estimated in this analysis would not be realised.

Summary of Assumptions

A summary of key assumptions made for valuation of the impacts is shown in Table 6.

Table 6: Summary of Assumptions

Variable	Assumption	Source
Impact 1: Increased Efficiency of AFMA Resource Allocation with respect to ERAs		
Total annual AFMA expense costs	\$31.02 million p.a.	AFMA, 2017b
Proportion of total AFMA expenditure used for ERAs for Commonwealth fisheries	1.0%	Agtrans Research, estimated based on research and other expense costs for AFMA in 2016/17 (AFMA, 2017b)
Estimated expenditure for ERAs	\$0.31 million p.a.	1% x \$31.02 m
Efficiency dividend due to improve prioritisation of AFMA habitat ERAs	2.5%	Agtrans Research
AFMA ERA expenditure required to achieve similar outputs WITHOUT dividend	\$0.32 million p.a.	\$0.31m x (1.025 / 1)
First year of impact	2016/17	Based on completion of project 2014-204
Period efficiency dividend delivery (years ended 30 June)	2017 to 2021 (then declining linearly to zero by 2025)	Agtrans Research
Impact 2: Enhanced Social Licence for Commonwealth Trawl Fisheries		
Total GVP of Commonwealth fisheries	\$438.8 million p.a.	ABARES, 2017
Percentage of fisheries potentially at risk of loss of social licence to operate	50%	Based on estimated value of Commonwealth trawl fisheries (see Table 1)
Value of fisheries potentially at risk	\$219.4 million p.a.	50% x \$438.8 m

Probability of impact of loss of social licence WITHOUT project 2014-204	10%	Agtrans Research
Value lost from fisheries WITHOUT project 2014-204	\$21.94 million p.a.	
Probability of impact WITH project 2014-204	9.5%	
Value lost from fisheries WITH project 2014-204	\$20.84 million p.a.	
Percentage of profit from GVP	10%	
Expected maximum profit benefit	\$0.11 million p.a.	
First year of impact	2016/17	Based on completion of project 2014-204
Period of impact (years ended 30 June)	2017 to 2021 (then declining linearly to zero by 2025)	Agtrans Research

Results

All past and future costs and benefits were expressed in 2017/18 dollar 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 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 7 and 8 show the investment criteria estimated for different periods of benefits for the total investment and the FRDC investment respectively. The present value of benefits (PVB) attributable to FRDC investment only, shown in Table 8, has been estimated by multiplying the total PVB by the FRDC proportion of real investment (63.0%).

Table 7: Investment Criteria for Total Investment in Project 2014-204

Investment Criteria	Years after Last Year of Investment						
	0	5	10	15	20	25	30
Present Value of Benefits (\$m)	0.00	0.56	0.70	0.70	0.70	0.70	0.70
Present Value of Costs (\$m)	0.41	0.41	0.41	0.41	0.41	0.41	0.41
Net Present Value (\$m)	-0.41	0.15	0.29	0.29	0.29	0.29	0.29
Benefit-Cost Ratio	0.00	1.38	1.72	1.72	1.72	1.72	1.72
Internal Rate of Return (%)	negative	14.8	19.6	19.6	19.6	19.6	19.6
MIRR (%)	negative	11.0	10.4	8.7	7.8	7.2	6.9

Table 8: Investment Criteria for FRDC Investment in Project 2014-204

Investment Criteria	Years after Last Year of Investment						
	0	5	10	15	20	25	30
Present Value of Benefits (\$m)	0.00	0.35	0.44	0.44	0.44	0.44	0.44
Present Value of Costs (\$m)	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Net Present Value (\$m)	-0.25	0.10	0.19	0.19	0.19	0.19	0.19
Benefit-Cost Ratio	0.00	1.39	1.73	1.73	1.73	1.73	1.73
Internal Rate of Return (%)	negative	15.4	20.3	20.3	20.3	20.3	20.3
MIRR (%)	negative	11.3	10.6	8.8	7.8	7.3	6.9

Contribution of Benefits

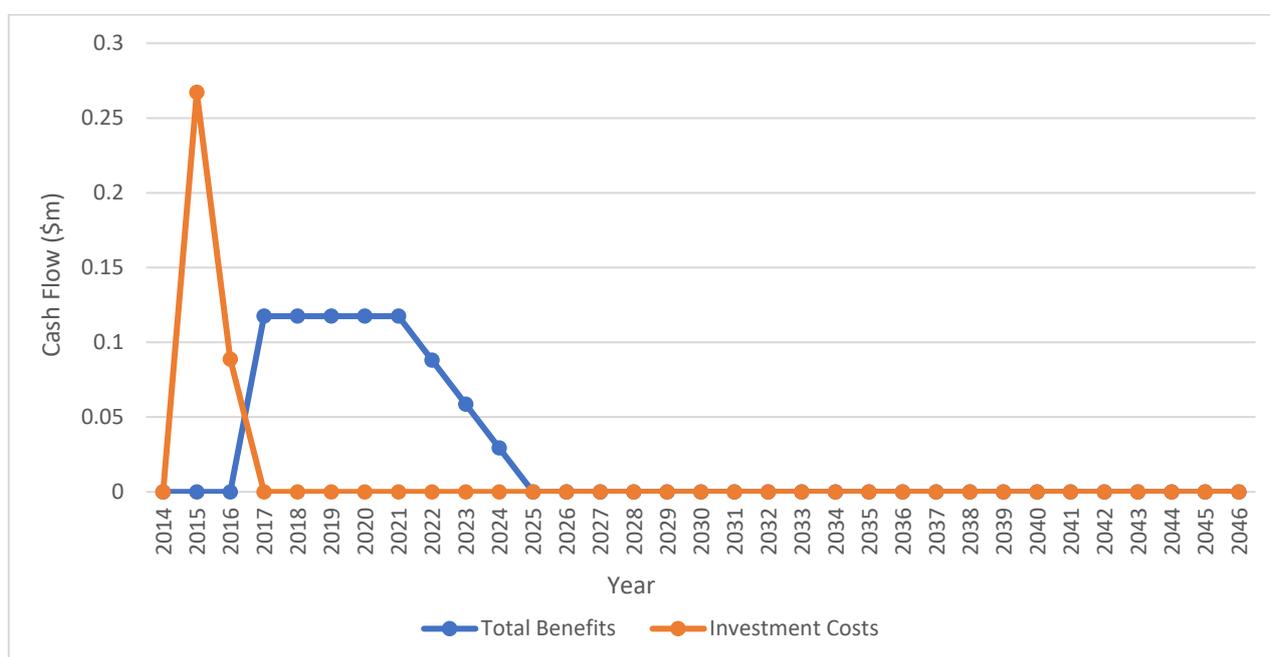
Table 9 shows the contribution of each impact to the total PVB for project 2014-204.

Table 9: Contribution of Benefits to Total PVB

Impact Valued	PVB (\$m)	Proportion of Total PVB (%)
Impact 1: Improved efficiency for AFMA ERA resource allocation	0.05	6.6
Impact 2: Enhanced social licence for Commonwealth trawl fisheries	0.65	93.4
Totals	0.70	100.0

The annual undiscounted benefit and cost cash flows for the total investment for the duration of the project 2014-204 investment plus 30 years from the last year of investment are shown in Figure 1.

Figure 1: 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 10 presents the results. The results showed a low sensitivity to the discount rate. This is largely because the expected future benefits from the project are short-term and occur in first 10 years after the last year of investment.

Table 10: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits (\$m)	0.76	0.70	0.65
Present value of costs (\$m)	0.36	0.41	0.46
Net present value (\$m)	0.41	0.29	0.19
Benefit-cost ratio	2.15	1.72	1.41

A sensitivity analysis was undertaken for the assumption of the efficiency dividend for Impact 1 (increased efficiency of AFMA resource allocation for ERAs) as this was a variable with some uncertainty. The results, reported in Table 11, showed a low to moderate sensitivity to the assumption of the efficiency dividend. This is because Impact 1 was the smaller of the two impacts valued, contributing only approximately 6.6% to the total PVB (Table 9).

Table 11: Sensitivity to the Efficiency Dividend for AFMA ERA Resource Allocation
(Total investment, 30 years)

Investment Criteria	Efficiency Dividend Assumed		
	0.5%	2.5% (base)	10%
Present value of benefits (\$m)	0.66	0.70	0.84
Present value of costs (\$m)	0.41	0.41	0.41
Net present value (\$m)	0.26	0.29	0.43
Benefit-cost ratio	1.63	1.72	2.06

A sensitivity analysis also was undertaken for the assumption of the probability of impact from loss of social licence with the investment in project 2014-204 as this variable was a key driver of the investment criteria and was a variable with some uncertainty. Results reported in Table 12 show a moderate to high sensitivity to the assumption of the reduced probability of a loss of social licence. A break-even analysis was then conducted on the assumed change in probability of loss of social licence due to the project. This analysis indicated that investment criteria were positive (benefit-cost ratio of 1) with a probability of approximately 9.72%, compared to the probability of 10% without the project.

Table 12: Sensitivity to the Probability of Impact of Loss of Social Licence WITH the Investment in Project 2014-204 (Total investment, 30 years)

Investment Criteria	Probability of Impact of Loss of Social Licence		
	7.5%	9.5% (base – with project 2014- 204)	9.75%
Present value of benefits (\$m)	3.32	0.70	0.37
Present value of costs (\$m)	0.41	0.41	0.41
Net present value (\$m)	2.91	0.29	-0.03
Benefit-cost ratio	8.16	1.72	0.92

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 13). 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 13: Confidence in Analysis of Project

Coverage of Benefits	Confidence in Assumptions
Medium-High	Low

The coverage of benefits was assessed as medium to high as the two impacts valued were considered the primary and most significant impacts from the investment (increased efficiency of AFMA ERA resource allocation and enhanced social licence for Commonwealth trawl fisheries). On the other hand, while some assumptions were supported by data and information obtained through public reports and consultation with the project Principal Investigator, the levels assumed for many assumptions were uncertain (in particular, the efficiency dividend and the change in probability of impact from loss of social licence assumed). Therefore, confidence in assumptions was assessed as low.

Conclusions

The investment in this project has provided trawl exposure and protection assessment information using an assemblage method for Commonwealth trawl fisheries that is likely to have provided AFMA with valuable information that may be used to identify priorities and/or gaps regarding the need for future habitat ERAs. This improved prioritisation is likely to increase the efficiency of resource allocation for AFMA habitat ERAs and, as a result, may contribute to enhanced social licence to operate for Commonwealth trawl fisheries.

Funding for the project totalled \$0.41 million (present value terms) and produced estimated total expected benefits of \$0.70 million (present value terms). This gave a net present value of \$0.29 million, an estimated benefit-cost ratio of 1.7 to 1, an internal rate of return of 19.6% and a modified internal rate of return of 6.9%.

While some environmental and social impacts identified were not valued, these impacts were considered minor when 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 investment costs:	The discounted value of investment costs.

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