FINAL REPORT

Non-Market Impact Valuation for Fisheries RD&E – Phase I

An Investigation and Gap Analysis of Non-Market Impact Valuation Studies for Australian Fisheries and Aquaculture RD&E

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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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Abbreviations & Acronyms

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
AGD	Amoebic Gill Disease
Agtrans	Agtrans Pty Ltd T/As Agtrans Research and Consulting
AIATSIS	Australian Institute of Aboriginal and Torres Strait Islander Studies
CER	Certified Emission Reduction
CGE	Computable General Equilibrium
CICES	Common International Classification of Ecosystem Services
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWE	Department of Agriculture, Water and the Environment (Commonwealth)
EU	Europe
FRDC	Fisheries Research and Development Corporation
GBRMPA	Great Barrier Reef Marine Park Area
HP	Hedonic Pricing
HWBI	Human Wellbeing Index
MPA	Marine Protection Area
NCEconomics	Natural Capital Economics Pty Ltd
NOK	Norwegian Krone
NRM	Natural Resource Management
NSW	New South Wales
NUV	Non-Use Value
OH&S	Occupational Health and Safety
PGPA	Public Governance, Performance and Accountability
QALY	Quality-Adjusted Life Year
R&D	Research and Development
RD&E	Research, Development and Extension
RDC	Research and Development Corporation
RP	Revealed Preference
SA	South Australia
SBT	Southern Bluefin Tuna
SE	South East
SEEA:EEA	System of Environmental Economic Accounting: Experimental Ecosystem Approach
SFA	Statutory Funding Agreement
SP	Stated Preference
TEV	Total Economic Value
UK	United Kingdom

US EPA	United States Environmental Protection Agency
USA	United States of America
USD	US Dollar
UV	Use Value
VASL	Value of a Statistical Life
WA	Western Australia
WHO-5	World Health Organisation- Five Wellbeing Index
WTP	Willingness-to-Pay
YTK	Yellowtail Kingfish

Executive Summary

This report, titled '*Non-Market Impact Valuation for Fisheries RD&E – Phase I: An Investigation and Gap Analysis of Non-Market Impact Valuation Studies for Australian Fisheries and Aquaculture RD&E*', presents the findings of the first stage of a process to assess and compile relevant, publicly available, non-market impact valuation studies for potential use in future Fisheries Research and Development Corporation (FRDC) research, development and extension (RD&E) impact assessments. The report also provides an assessment of the major gaps in the available non-market information related to the environmental and social impacts of fisheries RD&E to inform and prioritise potential future WTP studies. The project was funded to address a recommendation made in the FRDC's November 2018 Independent Performance Review conducted by Forest Hill Consulting that stated: *'FRDC should develop and implement with its impact assessment provider a project to assess willingness-to-pay studies of environmental attributes of fishery resources and externalities arising from aquaculture as input into future assessments of the environmental impacts of FRDC's Environment Program.'*

A desktop review and assessment of the range and types of impacts attributable to past FRDC RD&E investments was undertaken. Impacts identified from past evaluations then were categorised in a triple bottom line framework. Environmental and social impacts were subsequently summarised to create a short-list of major fisheries and aquaculture RD&E (hereafter referred to as 'fisheries RD&E') environmental and social impact types. The short-list of key environmental and social impact types was used to inform a comprehensive literature review of non-market valuations of environmental and social impacts associated with fisheries RD&E. Following completion of the literature review, a reference list/ database of available non-market valuation studies was developed in Microsoft Excel®.

Utilising the summary of environmental and social impacts from fisheries RD&E in Australia and the non-market valuation studies database, a gap analysis then was undertaken to identify the environmental and social impacts of Australian Fisheries and Aquaculture RD&E where credible non-market valuation data were not available. A brief review/summary of existing non-market valuation methods was completed. Each method was briefly described, and the pros and cons outlined. The project team then assessed the existing non-market valuation methods against the priority non-market valuation areas identified through the gap analysis and a recommendation was made as to which method(s) may be most suitable for future non-market studies related to the environmental and social assets identified.

The study produced a database of existing non-market valuation studies that should be a useful resource for future impact assessments/evaluations of fisheries and aquaculture RD&E investments. Through the FRDC RD&E impact review and the non-market literature review and gap analysis, the assessment found that the main areas requiring further impact estimation studies in Phase II of the process include:

- Value of fisher satisfaction,
- Contribution of fish habitat to carbon sequestration and storage,
- Willingness to pay for maintenance of biodiversity and/or ecosystem conservation,
- Willingness to pay for fish welfare, particularly farmed fish,
- Industry stakeholders' WTP for improvements to human health and wellbeing, and
- Social equity and maintained or enhanced social capital for fishers and fishing communities.

Further, though some international literature exists for a few of the above priority areas, there are limited Australian studies from which to draw relevant information and data. Also, though there is a deep literature on biodiversity and species protection values, such studies are typically species and/or site specific, therefore there is considerable space for FRDC to contribute to the body of literature for biodiversity issues specifically relevant to Australian fisheries and aquaculture.

It is recommended also that the FRDC periodically review available Australian and international non-market valuation literature and update the non-market study database. This will ensure that impact valuation data remain current and valid to demonstrate the benefits of fisheries and aquaculture RD&E.

Keywords

Impact assessment, non-market valuation, evaluation, cost-benefit analysis, gap analysis, willingness-to-pay, environmental and social impacts, ecosystem services

1. Introduction

1.1 Background

1.1.1 The Fisheries Research and Development Corporation

The Fisheries Research and Development Corporation (FRDC) is a statutory corporation within the Australian Government's Agriculture and Water Resources portfolio under the Department of Agriculture, Water and the Environment (DAWE)[1]. Revenue for Research, Development and Extension (RD&E) investment comes from a co-funding model between the Australian Government and the commercial fishing and aquaculture industries of Australia. FRDC was formed in July of 1991 and operates under the Primary Industries Research and Development Act 1989, and the Public Governance, Performance and Accountability (PGPA) Act 2013.

Each year, FRDC reports on performance (achievements of specified targets and overall performance) to DAWE. FRDC's Statutory Funding Agreement (SFA) with DAWE includes specifications that FRDC must:

- Develop and maintain a Program Framework to support its planning, performance and accountability requirements under the PGPA Act, and
- Develop an Evaluation Framework that supports the Program Framework. This Framework also must include a structured plan for the systematic evaluation of the efficiency, effectiveness and impact of the FRDC's key investments.

The Program and Evaluation Frameworks were published by FRDC in November 2016 and can be downloaded from https://www.frdc.com.au/about/performance-reporting.

1.1.2 The FRDC Annual Impact Assessment Program

In April 2017, FRDC contracted Agtrans Research to undertake a series of annual ex-post impact assessments on individual RD&E investments (projects) using a stratified random sample approach. The impact assessments serve several purposes:

- They provide a key input into FRDC's assessment of its program performance regarding impact against its2015-2020 RD&E plan and inform future directions of investment,
- They provide information that can be used in FRDC annual reporting to the Australian Government,
- They contribute to populating the Evaluation Framework for FRDC reporting to DAWE under the current SFA agreement, and
- They provide FRDC's input to the overall performance assessment of the Australian Research and Development Corporations (RDCs) compiled by the Council of Rural RDCs on a biennial basis.

To date, 60 impact assessments (20 each year) have been completed for randomly selected FRDC investments for projects completed in the years ended 30 June 2016, 2017 and 2018. A further 20 are due to be completed by October 2020 for a sample of projects completed in the 2019 financial year.

[1] Formerly the Department of Agriculture and Water Resources.

Many of the impacts identified for FRDC funded RD&E can be categorised as environmental or social impacts that are particularly difficult to value in monetary terms. One of the key recommendations to come out of FRDC's annual impact assessment process was that FRDC should explore available non-market impact valuation studies, and potentially fund additional willingness to pay (WTP) type studies, to improve data available for the valuation of environmental and social impacts. This, in turn, would significantly improve the impact assessment process and contribute to improved reporting of FRDC's overall performance.

1.1.3 FRDC's Independent Performance Review 2018

FRDC's SFA with DAWE requires that an independent performance review be completed six months before the expiration of the current agreement. So, in 2018, an independent performance review of FRDC was conducted by Forest Hill Consulting[2]. The review concluded that FRDC is a well-managed, high-performing organisation and that there is good evidence of the delivery of benefits to levy payers, Government, and other investors from FRDC investments. The review also identified several areas where improvements might be made. Ten specific recommendations were listed. One such recommendation was:

> *10. FRDC should develop and implement with its impact assessment provider a project to assess willingness-to-pay studies of environmental attributes of fishery resources and externalities arising from aquaculture as input into future assessments of the environmental impacts of FRDC's Environment Program.*

After completion of the review, FRDC committed to commissioning its external provider (currently Agtrans Research) to undertake work to improve the non-market valuation of FRDC RD&E impacts.

1.2 Rationale for the Current Project

The current project, titled *'Non-Market Impact Valuation for Fisheries RD&E – Phase I: An Investigation and Gap Analysis of Non-Market Impact Valuation Studies for Australian Fisheries and Aquaculture RD&E'* represents the first stage (assessment of WTP studies) of a process to assess and compile relevant, publicly available, non-market impact valuation studies for potential use in future FRDC RD&E impact assessments. The study also provides an assessment of the major gaps in the available non-market information related to the environmental and social impacts of fisheries RD&E to inform and prioritise potential future WTP studies.

[2] The FRDC Performance Review was completed in November 2018 and can be found at: https://www.frdc.com.au/about/corporate-documents/funding-agreement

2. Objectives

The overall aim of the project was to provide FRDC with a comprehensive database of available literature/ data and other information that could be used as a base to improve the valuation of impacts within the FRDC Annual Impact Assessment Program in the future. Specific objectives of the project were to:

- Assess and compile relevant, publicly available, non-market impact valuation studies for potential use in future FRDC RD&E impact assessments, and
- Identify and prioritise the major data/information gaps in the available non-market information related to environmental and social impacts of fisheries RD&E to inform potential future willingness to pay studies.

3. Method

3.1 Assessment of Impact Types

A desktop review and assessment of the range and types of impacts attributable to past FRDC RD&E investments was undertaken. Impacts identified from past evaluations then were categorised in a triple bottom line framework. Environmental and social impacts were subsequently summarised to create a short-list of major fisheries and aquaculture RD&E (hereafter referred to as 'fisheries RD&E') environmental and social impact types.

3.2 Literature Review and Gap Analysis

The short-list of key environmental and social impact types was used to inform a comprehensive literature review of non-market valuations of environmental and social impacts associated with fisheries RD&E. Publicly available, relevant literature (both from Australian sources and international studies) related to non-market valuation of environmental and social impacts of fisheries RD&E were identified and described. Following completion of the literature review, a reference list/ database of available non-market valuation studies was developed in Microsoft Excel®. The available non-market studies within the database also were linked to the short-listed environmental and social impact types previously identified in past FRDC impact assessment reports. The reference list was designed to be used as a resource to potentially inform future FRDC RD&E impact assessments (e.g. for benefit transfer valuation approaches).

Utilising the summary of environmental and social impacts from fisheries RD&E in Australia and the non-market valuation studies database, a gap analysis was undertaken to identify the environmental and social impacts of Australian Fisheries and Aquaculture RD&E where credible non-market valuation data were not available. An assessment was then made as to the relative importance of the data/information gaps to identify and prioritise key areas to be addressed by future, primary non-market valuation studies potentially to be funded by FRDC and/or others. The assessment also included a description of a range of ecosystem services and social outcomes associated with Australian Fisheries and Aquaculture RD&E impacts that could be used as the basis for future non-market valuation studies.

3.3 Review of Existing Non-Market Valuation Methods

A brief review/summary of existing non-market valuation methods was completed. Each method was briefly described, and the pros and cons outlined. The project team then assessed the existing non-market valuation methods against the priority non-market valuation areas identified through the gap analysis and a recommendation was made as to which method(s) may be most suitable for future non-market studies related to the environmental and social assets identified.

Also, based on the assessment and recommendation of non-market valuation methods, key expert personnel and/or organisations with suitable non-market valuation experience were identified. These personnel may be contacted to undertake future non-market valuation studies in specific areas, or to provide advice, support and/or resources to others that complete such studies.

3.4 Synthesis

The review of fisheries RD&E impact types, comprehensive literature review, gap analysis, review of non-market valuation methods and project recommendations were synthesised and compiled into a full project report submitted to FRDC.

4. Review and Assessment of Fisheries and Aquaculture RD&E Impact Types

4.1 Introduction

Over the past 10 years, Agtrans Research (Agtrans) has carried out a wide range of evaluations/ impact assessments of FRDC RD&E investments. Table 1 summarises the evaluations completed by Agtrans since 2010.

Table 1: Summary of Impact Assessments of FRDC Investments Undertaken by Agtrans

Year	**Evaluation Title/ Description**	**No. of FRDC Investments Evaluated**
2010	Economic Assessment of Randomly Selected Clusters of Investments of the Fisheries Research & Development Corporation	220 projects across 18 randomly selected clusters
2012	Economic Impact Assessment of Eight Clusters of FRDC Completed R, D&E Projects. Project Number: 2011/504	173 projects across eight clusters
2015	Economic Impact Assessment of Nine clusters of FRDC Completed RD&E Projects. Project Number: 2011/504	202 projects across nine clusters
2017	Evaluation of R&D projects completed in years ending June 2016 to June 2018. 2015/16 FRDC Evaluations (Year 1) Aggregate Report	20 projects – evaluated at an individual project level across five FRDC R&DE Programs
2018	Evaluation of R&D projects completed in years ending June 2016 to June 2018. 2016/17 FRDC Evaluations (Year 2) Aggregate Report	20 projects – evaluated at an individual project level across five FRDC R&DE Programs
2019	Evaluation of R&D projects completed in years ending June 2016 to June 2018. 2017-18 FRDC Evaluations (Year 3) Aggregate Report	20 projects – evaluated at an individual project level across five FRDC R&DE Programs
Total		655 FRDC RD&E projects evaluated between 2010 and 2020

Within each of the past FRDC RD&E impact assessments, a variety of economic, environmental, and social impacts associated with fisheries RD&E was identified. It had been observed that many of the impacts for FRDC funded RD&E categorised as environmental or social impacts are particularly difficult and/or complicated to value in monetary terms and may involve the application of complex and resource intensive non-market valuation methods. The following sections provide a review and assessment of the impacts reported for fisheries RD&E funded by FRDC to provide a foundation for the non-market valuation literature review and gap analysis later in this report (Section 5).

4.2 Identification of Impacts from Past FRDC RD&E Investments

Each of the past FRDC impact assessment reports was reviewed and the triple bottom line (economic, environmental, and social) impacts for each investment were identified and summarised in Table 2 below.

Table 2: Summary of Impacts Identified from Past Impact Assessments of FRDC RD&E Investments

FRDC RD&E Evaluation/ Impact Assessment Report	**Investment (Cluster/ Project)**	**Triple Bottom Line Impacts Reported**		
		Economic	**Environmental**	**Social**
Economic Assessment of Randomly Selected Clusters of Investments of the Fisheries Research & Development Corporation (2010)	Cluster 2: Aquaculture Diet Development Program	• Improved productivity in Barramundi production (e.g. higher growth rates, lower feed inputs for same level of production) • Greater confidence to commercial feed manufacturers to replace imported fish meal with Australian-based raw materials resulting in increased demand for products from Australian feed producing industries • Reduced risk of price fluctuations, quality variation and physical shortages due to less fish meal being used • Lowered costs of larvae from new rearing and feeding systems potentially benefitting a range of Australian aquaculture industries • Local Artemia production providing a reduced risk of shortages and pathogens via reduced imports	• Higher water quality and a reduction in the frequency and incidence of algal bloom outbreaks due to feeds with higher digestibility • Potential biosecurity benefits from reduced reliance on Artemia	• Increased human capacity in the field of fish nutrition • Reduced risk from dependence on single enterprises and a broader diversification of income at both business and regional levels

	Cluster 5: Abalone Aquaculture Subprogram	• Reduced production costs due to earlier spawning, improved settlement rates and growth rates • Increased investor confidence due to improved mudworm control options • Reduction in inappropriate use of antibiotics with associated small cost reduction and potential market implications • Reduction in cost of production due to improved genetics • Potential reduction in future production costs due to lowered mortality due to diseases • Efficiency dividend from management as a subprogram	• Avoidance of chemical treatments for mudworm control • Reduction in inappropriate use of antibiotics with a reduction in the potential for a negative environmental impact • Improved understanding of abalone diseases in natural ecosystems	• Increased research capacity in new industry development
	Cluster 6: Southern Bluefin Tuna (SBT) Aquaculture Subprogram	• Lower total feed cost for some SBT farmers using baitfish due to use of a feed formulation program • Potential cost savings in formulating and using manufactured feeds including delivery and distribution • Contingency feeding strategy available should baitfish supply be interrupted (quantity or quality) or where the price of baitfish increases significantly • Potential for reducing mortality in young tuna by identifying disease free eggs of SBT (in preparation for the potential closure of the SBT life cycle allowing farmed fish to be	• Potentially reduced faecal nutrient loads • Enhanced biodiversity of Spencer Gulf Region with reduced impact on seagrasses, other marine species and scavengers • Potentially improved water quality for the environment	• Reduced regional impact of baitfish supply interruption and/or price increase • Education and training of postgraduate students • Avoided expected regional social impacts from disruption to overseas trade • Reduced health risk for Australian and overseas consumers of SBT • Research capacity increased due to training of PhD student associated with this investment • Better informed community regarding aquaculture

		developed from eggs rather than wild capture) • Greater capacity by producers to anticipate, monitor and guard against fish health related incursions in tuna farms and hatcheries • Improved focus on research needs • Retention of existing market access to Japan and Europe (EU) for farmed SBT from South Australia (SA) • Increased competitive position for Australian farmed SBT over competitor products marketed in Japan, leading to opportunities for increasing demand and price and expansion of the Australian industry • Increased demand for SBT in other non-Japanese markets • Increased confidence that the SBT industry can be developed further and can meet planning regulations • Improved risk management of potentially significant events such as storms • Improved health of fish and quality of product • Spinoff economic benefits to other industries such as tourism and diving • Potential improvements in the long-term efficiency of production systems for SBT including feeding and health		operations due to workshops and web site

		• Infrastructure support for experimentation, more efficient allocation of research resources, more cost effective and relevant outcomes, and higher and earlier adoption through improved industry involvement and communication		
	Cluster 7: Salmon Aquaculture Subprogram	• Some potential for productivity improvements for Atlantic Salmon farmers where monitoring data is used for adaptive management • Avoidance of potential productivity losses for commercial fisheries (both aquaculture and wild-catch) due to decline in water quality that could occur without the research • Avoidance of other lost income associated with a decline in water quality, such as tourism and recreational fishing • Ensuring appropriate levels of expansion for industry due to improved accuracy in public perception of industry impacts • Reduced loss of industry value due to Amoebic Gill Disease (AGD) • More efficient future research due to improved research techniques • Strategic knowledge that can be used by the breeding program and other research projects for improving the long-term efficiency of production systems for Atlantic Salmon including	• Avoidance of water quality degradation and associated biodiversity losses • Avoided use of chemicals for disease management	• Maintenance of a profitable and sustainable Atlantic Salmon farming industry in Tasmania, and associated stability benefits to workers and the community • Avoidance of loss of amenity associated with water quality degradation • Improved research capacity relating to AGD • Improved research capacity (which is also being used for Yellowtail Kingfish (YTK), Barramundi etc.) • Workshops and public conferences improve the perception of the industry as professional

		disease management, growth rates and food quality and nutrition • Elimination of harvest gap, allowing sale (and provision to consumers) of fresh fish year round and avoiding discounted pricing for frozen fish • Increased growth, resulting in decreasing production cycle by 6 weeks • Delayed maturation, avoiding losses due to fish becoming unsaleable due to flesh quality and colouration • More efficient allocation of research resources and higher and more timely adoption of research outputs through improved industry involvement and communication		
	Cluster 8: Environmental Impacts on fishing	• Reduced impact of acid sulphate soils on NSW and other fisheries • Reduced likelihood of fishing activity around the Abrolhos Islands being inappropriately curtailed • Improved commercial sustainability of native inland eel fishery in Tasmania • Improved commercial sustainability of estuary dependent fisheries in Queensland	• Improved sustainability of native eel fishery in Tasmania • Improved biological sustainability of estuary dependent fisheries in Queensland	• More efficient use of research resources through improved priority setting and coordination
	Cluster 11: Ecological Sustainable	• Improved access to fish resources for a wide range of wild-catch fisheries • Reduced use of industry and government resources in monitoring	• Increased environmental responsibility and improved sustainability of aquaculture and wild-catch fisheries	• Increased awareness and accounting of contribution of fisheries to communities when making resource use decisions

	Development and Management	and evaluating environmental status of industries • Potentially increased domestic and export demand from some consumers and markets who are highly environmentally conscious • Potential cost reductions along the supply chain through adoption of best management practices to address Environmental Management Systems • Increase in size of YTK aquaculture industry • Continued access to fishery resource for recreational fishing tournaments, with associated community economic benefits		
	Cluster 12: Spatial management and marine protected areas	• Reduced impact of the displaced catch leading to reduced financial impact of sales foregone and reduced impact on industry profits and employment in South East (SE) fisheries • Reduced impact on those providing inputs to the SE fisheries supply chain (e.g. processors, repairs and maintenance, suppliers) • Reduced compliance costs in SE fisheries due to greater industry ownership of the revised Marine Protected Areas (MPAs) • More efficient development of MPAs for other Australian fisheries	• Marginally improved set of biodiversity and conservation assets for the South East Region fisheries and potentially for other Australian fisheries as more MPAs are prescribed	• Reduced potential un-employment and adjustment costs in SE fisheries • Lowered impact on localised SE fishing communities and reduced social costs of disruption and dislocation of families, particularly in Tasmania • Reduced transaction and compliance costs for government • Potentially lowered social impact in other fishery regions

	Cluster 13: Aquatic animal health and pests (biosecurity)	• Reduced costs of production for silver perch farms, rock oysters, and YTK due to improved understanding of pests and diseases • Increased production and improved quality for prawns, Barramundi, abalone, SA oysters, and YTK • Contribution to reduced costs of pest and disease management for a range of aquaculture industries due to availability of minor use chemical permits • Potential for improved export access for abalone and oysters • Potentially saved costs for carp eradication programs • Increased efficiency of Research and Development (R&D) resource allocation for animal health R&D	• Reduced environmental impact of carp on waterways • Reduced likelihood of environmental impacts from chemicals used in aquaculture	• Reduced likelihood of health impacts from chemicals used in aquaculture • Improved scientific capacity for industry
	Cluster 14: Innovations in enhancing wild-catch fisheries	• Reduced costs of catching octopus • Reduced costs of production of farmed abalone and farmed Moreton Bay bugs • Renewal of commercial black bream fishing • Maintenance of access to the Great Barrier Reef Marine Park Area (GBRMPA) fishery	• Restoration of ecosystem health for some inland fisheries	• Enhanced value of recreational fisheries (Barramundi in Queensland and black bream in WA) • Maintenance of access to GBRMPA recreational fishery • Improved research capacity
	Cluster 17: Aquaculture technology -	• Potential contribution to improved health of farmed prawns or aquaculture species through improved basic knowledge on bacteria in aquaculture	• Minimisation of impact of aquaculture on the environment (pearls and YTK) through identification and management of potential risks	• Increased scientific capability • Increased sustainability of jobs in the aquaculture industry

	environmental aquaculture	• Improved access to areas for pearl aquaculture development, and therefore ability to expand industry • Improved access to areas for yellowtail kingfish aquaculture development, and therefore ability to expand industry • Reduced damage to cages and other equipment from sharks and marine mammals • Saved costs to YTK aquaculture producers due to efficiencies in cage location	• Reduced impact of aquaculture on sharks and marine mammals	
	Cluster 20: Food Safety	• Increased domestic and export demand for seafood in particular farmed oysters, both wild caught and farmed prawns and farmed kingfish • Reduced industry losses in the event of a food safety incident • Cost reductions along the oyster supply chain	• Nil	• Reduced public health risks from food poisoning • Reduced incidence and severity of allergic reactions in the seafood workforce
	Cluster 21: Market Development and Trade Access	• Increased domestic demand • Increased export demand • Cost reduction along the supply chain • Improved access to sustainable fish resources	• Improved environmental performance	• Food safety awareness and safety improvements in the seafood industry • Health benefits from increased fish consumption
	Cluster 22: Workplace health and safety	• Reduced health costs associated with Erysipelothrix and related skin infections in western rock lobster fishermen	• Nil	• Improved health of western rock lobster fishermen through reduced incidence and severity of Erysipelothrix and related skin infections

		• Avoided increased diving costs for the pearl diving industry through avoidance of changing diving systems • Saved pearl industry and regulator costs through efficiencies in data collection and management • Reduced health costs associated with workers in the seafood post-harvest sector • Reduced Occupational Health & Safety (OH&S) costs for the seafood post-harvest industry sector including fines and insurance		• Potential improved health and safety for members of diving industries other than the pearl industry (e.g. abalone) • Improved health and safety of workers in the seafood post-harvest sector
	Cluster 23: Knowledge extension - including workshops and conferences	• Higher returns to future R&D investment (e.g. improved certainty and continuity of research funding; better targeted research) • More effective management of wild-catch fisheries and aquaculture industries leading to industry cost reductions	• More effective resource and environmental management of wild-catch fisheries and aquaculture industries	• Increased social equity with regard to property rights and allocation of resource use • Enhanced social capital via improved industry/community cohesion of fisheries, aquaculture communities and the general community • Enhanced career satisfaction of Australian scientists • Improved capacity of Australian and overseas science effort
	Cluster 26: R&D and Industry strategic planning	• Higher returns to future R&D investment (clear priorities, better planning, increased ownership, higher adoption) in both wild-catch and aquaculture industries	• More effective R&D investment due to taking greater cognisance of resource and environmental issues	• Strengthened social capacity of fishing sectors and sub-sectors and improved equity and balance in research resource allocation and policy between commercial,

		• Improved coordination in industry structures, planning and adding value along the seafood supply chain resulting in cost reduction and more effective marketing and promotion		recreational and Indigenous interests • Improved social capacity and understanding between fishing interests and the wider community • More effective input from the fisheries (wild-catch) and aquaculture sectors into government policies
	Cluster 27: Population dynamics and stock assessments – Australian Fisheries Management Authority	• Potential for reduced catches for industry as a cost, at least in the short term; but potential for enhanced long-term economic benefits from Commonwealth managed fisheries due to information being used to maintain sustainability • Economic benefits to state managed fisheries similar to above • Potential for growth in aquaculture as wild fisheries become more sustainable, albeit at a lower fish take in the short term	• Reduced likelihood of fisheries degradation • Lowered risk of damaging habitat, the ecosystem and biodiversity	• Potential short-term costs and longer-term benefits to fishing communities
	Cluster 28: Population Dynamics and Stock Assessment - Tropical	• Potential for reduced catches for industry as a cost, at least in the short term; but potential for enhanced long-term economic benefits from the fishery due to information being used to maintain sustainability • Changes in costs of stock assessment	• Reduced likelihood of fisheries degradation • Lowered risk of damaging habitat, the ecosystem and biodiversity.	• Potential costs and benefits to fishing communities

		• Potential for growth in aquaculture as wild fisheries become more controlled		
	Cluster 30: Population dynamics and stock assessments – NSW	• Potential for reduced catches for industry as a cost, at least in the short term; but potential for enhanced long-term economic benefits from the target fisheries due to information being used to maintain/increase sustainability • Potential for growth in aquaculture as wild fisheries become more sustainable, albeit at a lower take in the short term	• Reduced likelihood of fisheries degradation • Lowered risk of damaging habitat, the ecosystem and biodiversity	• Potential long-term benefits to recreational and cultural fishers from improved sustainability of species and associated fisheries
Economic Impact Assessment of Eight Clusters of FRDC Completed R, D&E Projects (2013) Project Number: 2011/504 (Round 1)	Appendix 1: An Economic Analysis of FRDC Investment in Theme 1: Biosecurity and Aquatic Animal Health (Part A)	• Reduced impact of AGD via improved management • Potential future reductions in impact of AGD via resistance breeding • Improved SBT health and stress management	• Potential for reduced noise impact of fish washing to remove AGD and carting fresh water to pontoons	• Enhanced research capacity • Reduced fish stress and enhanced animal welfare for both Atlantic Salmon and SBT
	Appendix 2: An Economic Analysis of FRDC Investment in Theme 2: Habitat and Ecosystem Protection (Part A)	• Maintenance of commercial viability of wild-catch fisheries associated with estuaries • Contribution to cost reductions for, and development of, the tuna and Atlantic Salmon aquaculture industries	• Potential contribution to sustainability of the estuarine and coastal water environment	• Scientific knowledge and capacity regarding fish habitats and stock assessment

	Appendix 3: An Economic Analysis of FRDC Investment in Theme 2: Habitat and Ecosystem Protection (Part B)	• Increased catch rate for commercial fishers • Industry cost savings • Maintain access to fishery • Increased industry capacity	• Retained ecosystems and species biodiversity	• Increased catch rate for recreational fishers • Public cost savings • Increased scientific knowledge
	Appendix 4: An Economic Analysis of FRDC Investment in Theme 11: Leadership Development	• Higher returns to R&D investment (e.g. more focused priorities, improved industry ownership of the research agenda) in both wild-catch and aquaculture industries. • Improved coordination in industry structures and national and sectoral research agenda planning and adding value along the seafood supply chain resulting in some cost reductions and more effective marketing.	• Enhanced ecosystem-based fisheries management	• Strengthened fishing industry sector and sub-sector leadership capacity. • More effective input from fishing sectors into national and state government policies.
	Appendix 5: An Economic Analysis of FRDC Investment in Theme 12: Workforce Development	• Industry cost savings • Greater R&D efficiency and effectiveness • Improvements in the workforce and skills base	• Improved fisheries and ecosystem management	• Built capacity • Reduced workplace accidents
	Appendix 6: An Economic Analysis of FRDC's Investment in Theme 13:	• Increased technical, scientific, business and leadership capacity within industry.	• Nil	• Improved national and state government policies from more effective input from fishing sectors.

	Innovation Skills (Part A)	• Strengthened industry development planning and policy (e.g. abalone; aquatic animal health). • Improved efficiency of research resource allocation.		• Improved capacity of individuals and groups to understand (e.g. between types of fishers and between community and industry) • More effective OH&S
	Appendix 7: An Economic Analysis of FRDC's Investment in Theme 13: Innovation Skills (Part B)	• More efficient research resource allocation • Enhanced industry development	• Enhanced ecosystems	• Enhanced understanding and support of indigenous cultural values • Improved governance capacity • Enhanced scientific research capacity
	Appendix 8: An Economic Analysis of FRDC's Investment in Theme 14: Extension and Adoption	• Enhanced industry development. • Improved efficiency of research resource allocation. • Increased scientific partnerships and capacity.	• Enhanced biodiversity and/or improved environmental impact	• More informed governance and policy decisions • Reduced conflicts
Economic Impact Assessment of Nine clusters of FRDC Completed RD&E Projects (2016) Project Number: 2011/504 (Round 2)	Appendix 1: An Economic Analysis of FRDC's Investment in Theme 1: Abalone, Yellowtail Kingfish and Oysters (Pearls and Edible)	• Increased yields/avoided yield loss • Avoided restriction on aquaculture expansion • Decreased production costs • Increased technical and scientific capacity • Increased industry capacity to be prepared for disease outbreaks	• Enhanced sustainability of ecosystems and the environment	• Increased technical and scientific capacity

	Appendix 2: An Economic Analysis of FRDC's Investment in Theme 4: Management (Part C)	• Increased sustainability of the wild-catch fishing resource • Increased access to resources (or avoided reduced access) by both wild-catch and the aquaculture industry • Reduced costs and or increased incomes • Improved research resource allocation • Increased industry/scientific capacity	• Maintenance or improvement in ecosystems and/or reduced biodiversity decline • Improved natural resource management by aquaculture industries	• Improved research resource allocation/public policy and governance • Increased scientific capacity
	Appendix 3: An Economic Analysis of FRDC's Investment in Theme 5: Governance and Regulatory Systems	• Increased net profits • Reduced management costs to industry • Increased industry capacity • Increased sustainability of fishery	• Enhanced sustainability of ecosystem/ reduction in loss of biodiversity	• Reduced management costs to government • Increased scientific capacity
	Appendix 4: An Economic Analysis of FRDC's Investment in Theme 6: Resource Access and Allocation	• Increased total utility • Reduced fisheries management costs • Improved industry and scientific capacity	• Enhanced sustainability of ecosystems and environment	• Avoided social costs • Reduced fisheries management costs • Improved industry and scientific capacity
	Appendix 5: An Economic Analysis of FRDC's Investment in Theme 7:	• Increased profits of aquaculture • Increased profits of wild-catch fisheries • Improved industry and scientific capacity	• Reduced environmental impact of production • Increased sustainability of wild-catch fisheries	• Improved scientific capacity

	Enhancement, Nutrition and Health			
	Appendix 6: An Economic Analysis of FRDC's Investment in Theme 7: Genetics/Selective Breeding	• Potential productivity gains via higher growth rates and lowered production costs via domestication and selective breeding • Enhanced industry and scientific capacity	• Nil	• Enhanced scientific capacity • Improved community wellbeing through increased aquaculture farm income and associated off-farm expenditure
	Appendix 7: An Economic Analysis of FRDC's Investment in Theme 7: Systems and Production	• Cost reduction in aquaculture operations. • Higher profitability from increased yields or higher growth rates. • Improved product quality. • Development of emerging aquaculture industries.	• Reduced impact of aquaculture and increased environmental sustainability	• Development of emerging aquaculture industries. • Increased efficiency of research expenditure.
	Appendix 8: An Economic Analysis of FRDC's Investment in Theme 7: Profitability	• Increased profitability of fisheries • Improved industry and scientific capacity	• Reduced environmental impact of production	• Improved scientific capacity
	Appendix 9: An Economic Analysis of FRDC's Investment in Theme 8: Consumers,	• Increased demand for seafood • Reduced costs along the supply chain and or increased incomes • Improved research resource allocation • Capacity building	• Environmental enhancement	• Benefits to consumers • Improved research resource allocation • Capacity building

	Products and Markets (Part A)			
Evaluation of R&D projects completed in years ending June 2016 to June 2018 2015/16 FRDC Evaluations (Year 1) (2018) FRDC Project No 2016-134	Aggregate level impacts (20 Projects)	• Net increase in profit or avoided loss • Increase in profits with positive environmental spill-overs • Increase demand or supply of product • Economic spill-overs to other industries • Lower operating costs • Product quality improvement • Increase in industry capacity • Improved RD&E resource allocation • Improvement in management efficiency and effectiveness	• Maintained or increased environmental sustainability • Species conservation status maintained or increased • Fish stock sustainability increased and/or maintained • Potential decrease in environmental sustainability	• Increased regional and government income and other social spill-overs • Enhanced social licence to operate • Enhanced reputation of government, fishers, and researchers • Increased scientific research capacity • Increased personal learning capacity • Improved human and fish wellbeing/ welfare
Evaluation of R&D projects completed in years ending June 2016 to June 2018 2016/17 FRDC Evaluations (Year 2) (2019) FRDC Project No 2016-134	Aggregate level impacts (20 Projects)	• Increased profitability/ productivity of fisheries, aquaculture and/or related industries (including through industry expansion, avoided economic loss, and increased consumer demand) • Increased or maintained economic sustainability and/or industry value (including maintained market access • Improved RD&E resource allocation • Improvement in management efficiency and effectiveness	• Maintained or increased environmental sustainability • Reduced risk of pests & diseases entry and/or establishment Australia	• Increased regional and government income and other social spill-overs • Enhanced social licence to operate / improved reputation of Australian fisheries and aquaculture industries • Increased scientific research capacity / enhanced reputation of Australian RD&E • Increased personal learning capacity • Improved human and/or fish wellbeing/ welfare

Evaluation of R&D projects completed in years ending June 2016 to June 2018 2017-18 FRDC Evaluations (Year 3) (2020) FRDC Project No 2016-134	Aggregate level impacts (20 Projects)	• Increased profitability/ productivity of fisheries, aquaculture and/or related industries • Increased or maintained economic sustainability and/or industry value (including maintained market access)	• Maintained or increased environmental sustainability, including improved environmental management of Australian fisheries/ aquaculture enterprises (e.g. reduced pollution from boats/ debris etc.) • Improved biodiversity (including reduced risk of negative biodiversity impacts • Reduced risk of pests & diseases entry and/or establishment Australia	• Increased regional and government income and other social spill-overs • Enhanced social licence to operate / improved reputation of Australian fisheries and aquaculture industries • Increased scientific knowledge or research capacity / enhanced reputation of Australian RD&E/ contribution to improved future RD&E • Increased personal learning, leadership capacity and/ or industry capacity • Improved human and/or fish wellbeing/ welfare

4.3 Summary of Environmental & Social Impact Types

The large number of environmental and social impacts identified in Table 2 were examined and then summarised into broad impact types. The impact types, listed below, were identified from the range of environmental and social impacts reported from FRDC RD&E investments evaluated between 2010 and 2020. These environmental and social impact types were then used as a foundation for the literature review presented in Section 5.

Note, the first-tier dot points below indicate the broad impact type identified while the second-tier dot points indicate potential impact drivers.

4.3.1 Environmental Impact Types

- Improved water quality:
  - Reduced frequency and incidence of algal blooms
  - Reduced/avoided chemical use (including antibiotics)
  - Reduced faecal nutrient loads
  - Avoided water quality degradation
- Improved aquatic/marine animal health/wellbeing/welfare:
  - Reduced risk of exotic biosecurity incursions (pests/diseases)
  - Reduced/avoided chemical use (including antibiotics)
  - Improved fisheries and/or aquaculture farming practices
- Improved ecosystem sustainability and health:
  - Increased understanding of diseases in natural ecosystems
  - Reduced faecal nutrient loads
  - Reduced/avoided chemical use (including antibiotics)
  - Reduced impact of invasive species (e.g. carp impacts for inland waterways)
  - Restoration
  - Minimised negative impacts and risks associated with aquaculture
  - Reduced risk of ecosystem damage
- Increased biodiversity (species diversity and abundance):
  - Avoided biodiversity loss
  - Reduced risk of biodiversity damage/loss
- Increased environmental sustainability of wild-catch fisheries and aquaculture
- Improved conservation of aquatic/ marine assets
  - Increased MPAs
- Improved environmental and natural resource management (NRM) for wild-catch fisheries and aquaculture
  - Reduced likelihood of fisheries degradation
  - Reduced risk of habitat damage
  - Reduced pollution from production-based activities
- Reduced noise and/or odours from fisheries/ aquaculture operations
- Aquatic/ marine species conservation status maintained or increased
- Aquatic/ marine species stock sustainability maintained or increased (particularly commercially harvested, wild-catch fish stocks)
- Reduced risk of pests & diseases entry and/or establishment Australia

4.3.2 Social Impact Types

- Increased scientific knowledge and/or research capacity/ capability
- Increased knowledge and/or leadership capacity/ capability associated with fisheries and/or aquaculture industries
- Increased health and/or wellbeing for fisheries and/or aquaculture producers:
  - Education, training and networking opportunities
  - Improved job stability and/or sustainability
  - Reduced business risk (e.g. through diversification, avoided disruption of trade)
  - Reduced risks of negative health impacts through reduced/avoided chemical use
  - Improved health and safety (including reduced workplace accidents)
  - Job/ career satisfaction
  - Reduced conflict (e.g. through improved mental well-being)
- Increased regional community wellbeing:
  - Spill-over benefits from increased industry productivity/ profitability
  - Reduced stress or negative health (physical and mental) outcomes
  - Reduced health risks (including from improved food safety, biosecurity, etc.)
  - Increased stability of key regional industries
  - Reduced unemployment costs
  - Reduced community disruption and/or dislocation of families in regional areas
  - Reduced risks of negative health impacts through reduced/avoided chemical use, reduced/avoided allergic reactions, reduced risk of infection/disease
  - Health benefits from increased consumption of fish products
- Maintained or enhanced social licence to operate for producers in fisheries and/or aquaculture industries:
  - Better informed community regarding fishery and/or aquaculture operations
  - Improved perception of fishery and/or aquaculture industries through stakeholder engagement
  - Improved aquatic/ marine animal health/ wellbeing
  - Enhanced understanding and support of indigenous cultural values
  - Enhanced reputation of government, fishers, and researchers
- Maintained or improved amenity:
  - Increased water quality or avoided water quality degradation
  - Enhanced value of recreational fisheries (e.g. through improved biodiversity)
  - Maintained access to recreational fisheries
  - Increased catch rate for recreational fishers
- Increased social equity (e.g. with regard to property rights and allocation of resource use and/or through reduced conflict)
- Maintained or enhanced social capital:
  - Improved industry/community cohesion
  - Improved equity and balance in resource allocation and policy between commercial, recreational and indigenous interests
  - Improved social understanding between fishing interests and the wider community
  - Enhanced understanding and support of indigenous cultural values
  - Reduced conflict

5. Review of the Literature: Non-Market Valuation Studies for Impacts of Fisheries RD&E

5.1 Introduction

The FRDC regularly reports on its performance to DAWE and the Australian fishing and aquaculture industries. These reports include a demonstration of achievements of specified targets and overall performance as measured by social, economic and environmental impacts. However, there has been a paucity of information available on the value of non-market benefits that accrue to the different fishing and aquaculture sectors and their associated communities. There is a growing body of literature, both in Australia and internationally, on how to quantify these non-market benefits. A literature review on Australian and international studies therefore was undertaken to document previous non-market impact valuation studies related to fisheries RD&E, as well as to identify gaps that would be worthwhile FRDC addressing in future.

This Section of the report provides a summary of the literature review including key types of non-market benefits, methodologies used, and, where available, the estimated values. A companion database in the form of a Microsoft Excel® spreadsheet has been developed summarising the studies reviewed for this report. This spreadsheet provides an easy-to-use point of reference for a rapid review of past studies, the valuation methods used, study locations, context, general themes and the estimated WTP values.

5.1 Method

A desktop approach was used to undertake the literature review. This involved a search in Google Scholar and a range of academic journal databases such as Scopus and Web of Science. There are some non-market valuation databases available also that may yield useful information. These databases are built from results of past studies. The project team did not review such databases as this is a key deliverable from another FRDC recently funded project by Coglan and team as part of the "Non-market values to inform decision-making and reporting in fisheries and aquaculture" (FRDC project no. 2018-068).

The benefit values from previous studies are reported as estimated in the original studies. The companion spreadsheet provides additional information (i.e. currency and survey/estimation year) to help the analyst adjust the reported values to common year Australian dollar value to provide comparison consistency.

5.2 Ecosystem services as a means to identify and scope value

A number of concepts and methods are relevant to this work. These include (1) a framework for scoping and categorising benefits, and (2) evaluation of methods for valuation of non-market and social benefits identified. These concepts and methods are briefly outlined in the following sub-sections.

5.2.1 Framework for scoping and categorising ecosystem services

Ecosystem services are the benefits people obtain from the natural environment. The current best practice framework for this approach is outlined in the Common International Classification of Ecosystem Services[3] (CICES).

The CICES has been developed by the European Environment Agency as part of a revision of the *System of Environmental Economic Accounting: Experimental Ecosystem Approach* (SEEA:EEA), currently being led by the United Nations Statistical Division. In Australia, development of the SEEA:EEA has had input from and is endorsed by various Australian Government departments, including the Australian Bureau of Statistics (ABS), the Bureau of Meteorology, and DAWE, among others.

[3] For further information see: https://cices.eu/resources/

The CICES ecosystem services are categorised into three broad types:[4]

1. *Provisioning services*: all the products obtained from ecosystems (e.g. raw water).
2. *Regulating and Maintenance services*: benefits obtained from the regulation of ecosystem processes (e.g. regulation of water quality, air quality, climate and erosion).
3. *Cultural services*: related to non-material benefits, for instance recreation, aesthetic experiences, and spiritual enrichment.

The conceptual framework of CICES is based on the cascade model shown in Figure 1. This model shows cause–effect relationships for how changes to the environment lead to changes in social and economic systems. The ecosystem services framework starts with the concept of ecosystem assets — defined as spatial areas containing a combination of biotic and abiotic components and other characteristics that function together. Examples of ecosystem assets include estuaries, wetlands, mangroves or coral reef ecosystems.[5] The extent and condition of these assets are influenced by pressures (e.g. water quality and fishing rates) and policy interventions aimed at alleviating these pressures (e.g. construction of wetland systems and imposing fishing restrictions on amounts, sizes or species). The functioning of ecosystem assets generates a range of 'services' that contribute to human wellbeing.[6] These services are known as ecosystem services and they are the 'final' outputs from ecosystems that most directly affect the wellbeing of people.[7] Services, in the cascade model (Figure 1), give rise to goods and benefits, as in the case of improved satisfaction values when anglers are able to catch fish. When these benefits are achieved, the 'production boundary' is crossed and the values of these benefits may be estimated in monetary terms using non-market valuation approaches.

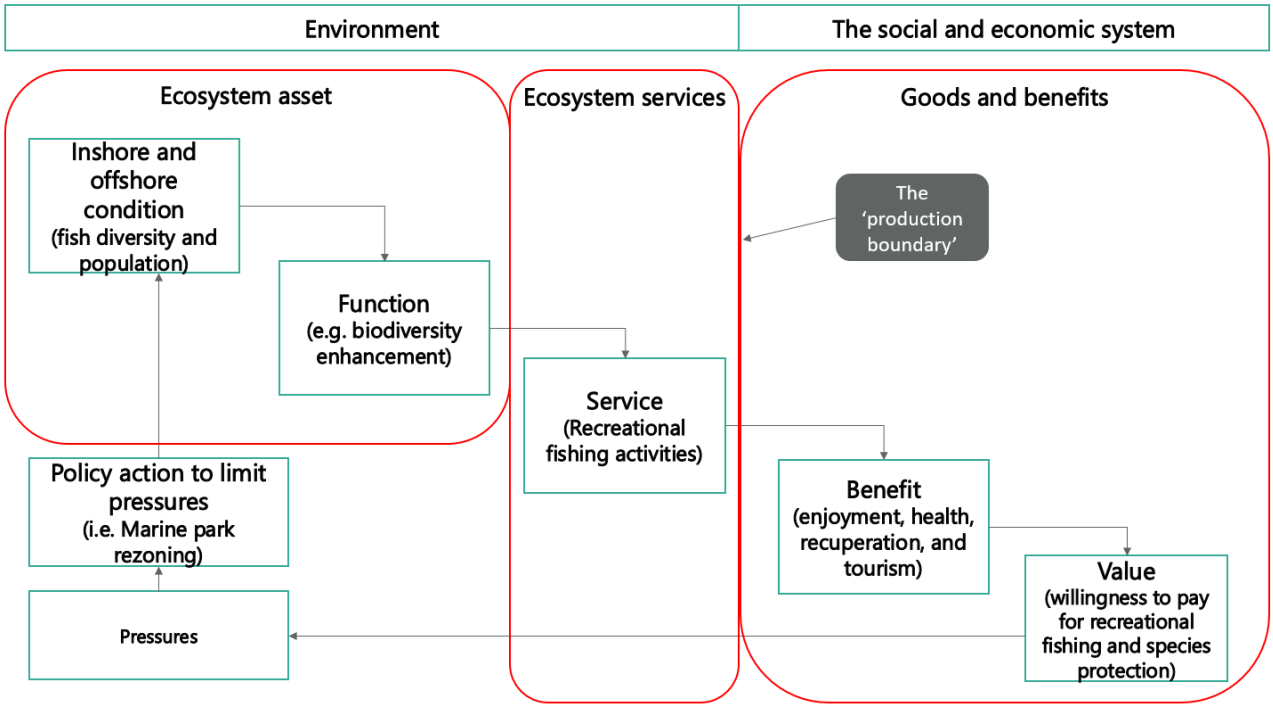

Figure 1. The Cascade Model of Ecosystem Services

Source: adapted from Potschin and Haines-Young (2016)

[4] All these three ecosystem services are underpinned by the 'supporting services' (FAO, 2019).
[5] Ecosystem assets are characterised in terms of *extent* and *condition*.
[6] CICES defines ecosystem services as the 'contributions that ecosystems (i.e. living systems) make to human wellbeing'.
[7] Haines-Young, R. and M.B. Potschin (2018): Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. Available from www.cices.eu.

It is important to note that natural capital assets (e.g. estuaries, mangroves, marine protection zones) can produce multiple ecosystem services simultaneously. The ecosystem services framework provides a systematic way to scope and then value the different benefits that may be associated with FRDC investment initiatives and management strategies.

5.2.1 Bioeconomic modelling

Bioeconomic models also are widely used in the fishing industry. Bioeconomic models are mathematical models used to analyse market prices, fishing effort over time (costs), harvest rate, growth rate, and biomass, among other variables. The basic models are generally used to assess profitability. While these models can be integrated with non-market valuation studies (particularly for conservation projects) they are themselves a tool conventionally used to assess management strategies against profitability. More sophisticated models can be tailored to incorporate land use management and ecosystem services (Castro et al., 2018; Wiedemann et al., 2016). These sophisticated models can be used to help make decisions about the need for protection for fisheries non-market ecosystem services (Cahill and Robard, 2014).

Bioeconomic models could potentially be used to identify key attributes for consideration in the design of stated preference studies. For example, bioeconomic modelling can be used to gain insights into the predator-prey dynamics (Wiedemann et a., 2016) such as the case where an increase in a fish stock may lead to an increase in bird populations at a given site. The non-market value of having a healthy fish stock and bird population in an ecosystem can then be estimated using non-market valuation methods. The scope of this study is non-market values and social benefits, and these are the focus for the rest of this report.

5.3 Literature review & Gap Analysis

Eight types of non-market values are discussed in this section. These types are based on recurring key themes around non-market valuation associated with fish, fishing, fisheries and aquaculture. These values include fisher satisfaction, recreational fishing, blue carbon, biodiversity and species protection, fish welfare, Indigenous Australian values, landscape and local amenity, and social benefits.

5.3.1 Value of fisher satisfaction – *cultural ecosystem service*

Satisfaction is the principal product of a recreation experience and it is the ultimate reward from an angler's fishing experience (Beardmore et al., 2015). Thus, the level of satisfaction with a fishing experience has an impact on the value placed on a fishing trip by recreational anglers. Satisfaction falls under the cultural services category in the ecosystem services framework.

Past studies that have shown that fishers place a satisfaction value for a fishing trip experience include Graefe and Fedler (1986), Holland and Ditton (1992), Spencer and Spangler (1992), Spencer (1993), Ezzy et al., (2012), and, Loomis and Ng (2012), Melstrom and Lupi, (2013). These studies have shown that anglers derive utility from the fishing experience and their utility is a function of the fishing site, catch rates, catch size, species, angler's age and accessibility by boat. For example, Loomis and Ng (2012) used a travel cost model and a contingent valuation model to estimate the WTP for trout and non-trout anglers. For both models, they found that WTP for trout anglers was more than double that of non-trout anglers. Spencer (1993) surveyed recreational fishers in Minnesota, USA and found that the primary motivations to engage in recreational fishing were: to catch fish, to enjoy nature and to be with people who are enjoying themselves. Thus, catching fishing and being outdoors/engaging with nature and socialising are important drivers of satisfaction and sustained engagement with fishing activities.

However, there has been a dearth of understanding of the relative WTP for these individual fishing trip attributes. Most recreational fishing valuation studies have focussed on WTP to get to and/or access a fishing site. Limited studies have been undertaken for WTP for some fish species for example trout (Loomis

and Ng, 2012), Southern Bluefin Tuna (Ezzy et al., 2012), and Atlantic Salmon, yellow perch, steel head and walleye (Melstrom and Lupi, 2013).

It is therefore likely that different WTP estimates exist for specific attributes such as site access, catch rates, catch size, and species types. An understanding of the relative importance of these different attributes will provide valuable information to fisheries and marine park managers to ensure that fishing sites are managed to provide the best social, economic and environmental outcomes. Enhanced fisher satisfaction is likely to boost recreation and physical activity leading to important community wellbeing outcomes through health[8] and social benefits.

Key points

Satisfaction is an important outcome for any recreational engagement.

Satisfaction is a function of several factors including site on-location attributes, accessibility, catch rates, catch size, species type, and angler attributes.

While a number of studies have been identified, very few relate to Australian fishing.

5.3.2 Recreational value of fishing – *cultural ecosystem service*

There are several Australian and international studies on the use of non-market valuation techniques to estimate consumer surplus for recreational fishing. Recreation is a key cultural service within the ecosystem services framework. Studies estimating consumer surplus tend to focus on the costs associated with accessing a site. However, the value of fisher satisfaction is a key driver of benefits estimated by these travel cost models but it is often not considered separately by these models. In some cases, the travel cost methodology is combined with a stated preference method to further elicit WTP values based on changes in location attributes or catch rates or species type.

In Australia, consumer surplus studies have included value from fishing in the Great Barrier Reef, freshwater dams, inshore salt waters, marine protected areas, coastal areas and at sea. Recent Australian studies include Windle et al. (2017), Pascoe et al. (2014), Raguragavan et al. (2013), Yamakazi et al. (2013), Ezzy et al. (2012), Prayaga et al. (2010), and Rolfe and Prayaga (2007), among others. Many of these studies rely on the travel cost method to estimate consumer surplus as a measure of non-market benefits to the fisher. Consumer surplus is the difference between the fisher's WTP and the actual costs they incur to engage in a recreational fishing activity (Pascoe et al. 2014).

Windle et al. (2017) used a travel cost model to estimate the value of recreational fishing at Gladstone Harbour, Queensland. They found that the consumer surplus to Gladstone households was $143 per recreational fishing trip. In another Queensland study, Pascoe et al. (2014) investigated the recreation value fishing in Moreton Bay Marine Park Area using a travel cost model and estimate a consumer surplus between $129 and $134 per trip per group, and about $60 per trip per individual.[9]

Raguragavan et al. (2013) undertook a state-wide economic evaluation of recreational fishing using a random utility model for fish and site choices in Western Australia (WA). On average, anglers were found to have WTP amounts of $31 for a 100% increase in catch-rates for prize fish and $23 for reef fish. The study also reported estimated access values for 48 sites ranging from $1.90 at Shark Bay Oceanic to $14 at Coral Bay (Raguragavan et al., 2013). These values were driven by the availability of nearby substitutes, estimated catch-rates and they indicated welfare loss per trip per recreational fisher.

The recreational value of fishing for Southern Bluefin Tuna was estimated by Ezzy et al. (2012). The study was undertaken at Portland, Victoria for non-commercial Southern Bluefin Tuna. Using a travel cost model,

[8] Health benefits include both physical and mental health benefits (Windle *et al.*, 2017)

[9] These estimates are based on the average marginal costs i.e. fuel costs for car travel and boat use and bait costs.

Ezzy et al. (2012) estimated the consumer surplus of $34 and $132 per person per trip. The higher estimate includes the incorporation of the opportunity cost of time, while the lower value does not.

Prayaga et al. (2010) combined the travel cost and contingent behaviour models to estimate the consumer surplus derived from a fishing trip in the Great Barrier Reef's Capricorn Coast. The travel cost model results indicate a consumer surplus value of $385 per group per trip or $167 per angler per trip. Assessment of contingent behaviour based on changes in catch-rates and other variables such as the probability of catching a legal-sized Red Emperor, crowding and algal blooms yielded little or no changes to the estimated benefits.

Rolfe and Prayaga (2007) applied travel cost and contingent valuation methods to estimate the recreational value of fishing in three major dams in Queensland. They used an individual travel cost model for frequent anglers, a zonal travel cost model for occasional anglers and a contingent valuation method for assessing the marginal values for improvements in fishing experience as measured by a 20% increase in catch rates. Rolfe and Prayaga (2007) estimated consumer surpluses for frequent anglers of $221, $359 and $441 per person per trip for Bjelke-Petersen, Boondooma and Fairbairn dams, respectively. Occasional anglers had values of $60, $348 and $904 per person per trip for Bjelke-Petersen, Boondooma and Fairbairn dams, respectively. Contingent valuation results indicate that anglers had average WTP values of $19, $43 and $35 per person per trip for Bjelke-Petersen, Boondooma and Fairbairn dams, respectively, for a 20% improvement in catch rates.

Yamakazi et al. (2013) undertook a contingent valuation study to estimate WTP for the most recent day's fishing at an inshore saltwater fishery and a rock lobster fishery in Tasmania. They estimated WTP values for the most recent fishing day of $169 per person for inshore saltwater fishery and $121 per person for rock lobster fishery. In contrast to survey findings by Beardmore et al. (2014), Yamakazi et al. (2019) found no significant difference in WTP estimates for a day of fishing between individuals who caught different numbers of fish. The Yamakazi et al. (2019) findings are consistent with those from Loomis and Ng (2012) where the catch rate coefficient was not significant and Prayaga et al. (2010) where the WTP values were relatively insensitive to changes in catch rates.

Australian non-market valuation studies have mostly relied on both the travel cost and contingent valuation methods. The travel cost model has been to estimate consumer surplus for engaging in a fishing activity while the contingent valuation method has been used to elicit WTP estimates for variations in overall catch-rates, probabilities for catching a specified fish species or other site related factors such as crowding and fishing site health status.

Similar approaches have been used internationally to estimate the value of recreational fishing (e.g. Alvarez et al., 2014; Melstrom and Lupi, 2013; Toivonen et al., 2004). As noted in a previous FRDC report, Coglan et al., (2019), other methods from international literature include hedonic pricing (Carter and Liese, 2010), discrete choice experiment (Börger et al., 2014), and meta-analysis (Johnston et al., 2005).

Key points

Several Australian studies have been undertaken to estimate the value of recreational fishing. Most of these have used the travel cost model. A few have used a contingent valuation to estimate WTP for improvements in the fishery or in the angler experience.

With sufficient data a robust travel cost model can be used to estimate reliable non-market values of a recreational fishing trip.

5.3.3 Blue carbon – *regulating ecosystem service*

A key area of investment by FRDC is best practice fisheries management and consequently, protection of primary ecosystem services from fishing areas. Such management activities have impacts on the health of the waterbodies and thus contribute to the health of aquatic plants such as mangroves, saltmarsh and seaweed. These plants provide an important regulating ecosystem service for a sustainable climate through

carbon capture and storage. Improvements in the health of these plants and the overall ecosystem contributes to several ecosystem services including carbon sequestration in addition to any fish habitat ecosystem services.

The recent and growing focus on carbon trading has increased interest in blue carbon. Blue carbon is the carbon sequestered (captured and stored) by coastal vegetated ecosystems such as mangroves, saltmarshes and seagrass.[10]

Based on 13 studies and 34 sites across the world, mangroves were estimated to have an average soil carbon sequestration rate of 226 g C m^{-2} per year (standard error of 39), while saltmarsh has a rate of 242 g C m^{-2} per year (standard error of 25.9) (Ouyang and Lee, 2014). In southeast Australia, Howe et al. (2009), estimated average mangrove sequestration rate in two wetlands to be 89 and 105 g C m^{-2} per year.

Zarate-Barrera and Maldonado (2015) estimated that a new network of MPAs in Colombia would increase the annual capture rates by 49-94% and lead to annual benefits ranging from 16 and 33 million euros over eight years. This estimate was based on the historic price of a certified emission reduction (CER) between August 2008 and May 2012 – the CER price ranged from €1.10 to €5.20 per tCO_2e. In Australia, Lavery et al. (2013) estimated that seagrass ecosystems have a carbon sequestration rate of 10.1 tonnes C km^{-2} per year and carbon storage volume of 155 million tonnes. Using a fixed carbon price of $25.40 per tonne, they estimated that the value of carbon stored in seagrass was $3.9 billion. [11]

There are some differences in the price of carbon reported and used to estimate the value of sequestered carbon. For example, in Australia the Emissions Reduction Fund has recorded auction prices ranging from $10.23 to $14.17 per tCO_2e. Similar low prices have been reported internationally through the CER (Phase 2 of the European Union Emissions Trading Scheme 2008-2012) and the voluntary Verified Emission Reductions (Chicago Climate Exchange 2003-2010). However, these pricing mechanisms underestimate the true social cost of carbon pollution as the damage caused by emissions is not accounted for in these prices. In 2009 the Institute of Policy Integrity undertook a survey of experts on climate change and the estimated median social cost of carbon was USD50 per tonne CO_2e (Howard and Sylvan, 2015). In a 2015 follow-up survey, over half of the experts indicated that they were of the view that the social cost of carbon was actually higher than the previous 2009 median value (Howard and Sylvan, 2015).[12]

While there are some variations in the price of carbon used in previous studies, there is nonetheless strong evidence that there are valuable benefits from blue carbon either through regulated or voluntary markets and/or non-market benefits such as those that may be enhanced by FRDC investment in RD&E to support improved environmental outcomes for saltwater fisheries (both marine and estuarine). For example, in 2017, participants in the National Seafood Industry Leadership Program challenged the Australian seafood industry to become carbon neutral by 2030. In response to this challenge, FRDC and CSIRO hosted a workshop in July 2018 that invited key stakeholders from the Australian seafood industry, government and non-government organisations. The aim of the workshop was to discuss the overall attitudes of the Australian seafood industry to the concept of blue carbon neutrality, and then gauge aspirations for investment in coastal blue carbon offsets as a way of achieving carbon neutrality. Developing partnerships between the seafood industry and like-minded businesses, to address key uncertainties and knowledge gaps (such as uncertainty over tenure, lack of reliable demonstration sites, absence of key data such as carbon accumulation rates) is likely to be a fruitful area for maximising the future blue carbon opportunities for the seafood industry (Vanderklift, Steven, Marcos-Martinez & Gorman, 2018).

[10] The FRDC is currently co-funding a study on the production of seaweed as a nutrient offset in Moreton Bay (FRDC no. 2019-32). Insights from this project could potentially be applied to other ecosystems such as mangroves, seagrass and saltmarsh.

[11] This estimate was based on the Australian government legislated carbon price of $25.40 before it was repealed in 2014. Auction results from the July 2019 Clean Energy Regulators indicate a price of $14.17, based on this price the value of carbon sequestered by seagrass will still be a significant $2.2 billion.

[12] After accounting for carbon pollution damages under different climate scenarios, the social cost of carbon was modelled to rise to between USD60 and USD375 (Howard and Sylvan, 2015).

Key points

While there are variations in the estimated carbon sequestration rates and carbon prices, previous studies indicated a significant market and non-market benefit from increasing blue carbon sequestration and storage.

FRDC is yet to demonstrate its contribution to the mitigation of greenhouse gases through regulation ecosystem services. Thus, there is an opportunity for valuing/monetising FRDC's contribution to greenhouse gas mitigation and improve the overall benefit estimation process.

The blue carbon economy also represents a potentially valuable financial gain through existing schemes such as the Reef Trust Funding from the Australian Government Department of Agriculture, Water and the Environment.

5.3.4 Biodiversity and species protection – *supporting and cultural ecosystem services*

Biodiversity is important for the future of sustainability of natural fisheries used for both recreational and commercial purposes (Hiddink et al., 2008). Thus, in addition to the recreational and commercial benefits derived from fisheries, there is also an underlying non-market value for the protection of habitats and species which are often at risk of pests, diseases and over-extraction. The biodiversity and species protection benefits provide a supporting service to all other services and some of the values may also be linked to cultural services e.g. WTP for bequest or existence values or option value.[13]

Assessment of non-market values to manage risk to biodiversity, habitats and/or species have been undertaken. Mazur et al. (2018) investigated the community's WTP for management actions to help prevent the incursion of marine pests in Australian waters. They used a choice model and found that individual households were willing to pay an average of $16.3 per year to protect one species and $9.3 per 250 km of coastal and adjacent waters if there was a 50% chance that the outcome will be realised. This WTP value may represent any or all of the following: existence, bequest and option values.

As a response to increasing anthropogenic pressures on offshore marine environments in the UK, Borger et al. (2014) investigated the public's WTP for conservation benefits arising from a marine protected area – the Dogger Bank MPA. They found significant and positive WTP values for an increase in species diversity, protection of certain charismatic species (i.e. porpoises, seals and seabirds) and restriction of the spread of invasive species. They estimated an average annual WTP for species diversity of £4.95 and £7.50 per household and £25.13 and £31.70 per household per year for the protection of charismatic species on 25% and 50% respectively of the Dogger Bank MPA.

Parsons and Thur (2008) used a choice model to estimate the annual loss in value associated with decline in coral reef quality for US divers in the Caribbean. They estimated annual losses in value equivalent to $46, $143 and $193 per person, for declines to good, medium and poor-quality levels.

An Australian study by Wilson and Tisdell (2003) investigated Australians' and foreigners' (tourists) WTP for the protection of marine wildlife in Queensland. They found that Australian individuals were willing to pay $2.15 per week over 10 years to protect sea turtles and $2.41 per week over 10 years to protect whales. International tourists had higher WTP values at $2.67 and $4.09 for sea turtles and whales, respectively.

Fisheries attract both fishing and non-fishing recreation visits. Thus, both freshwater and saltwater fisheries provide for non-extractive recreational benefits. The non-market values from non-fishing recreation

[13] Existence value relates to the utility derived from simple knowledge of the existence of a resource. Bequest value is the satisfaction that individuals derive from knowing that a resource will be preserved for use by future generations. Option value is the value placed on a good or service by people because they want to have an option to consume it at a future time, where consumption is uncertain.

engagements include marginal WTP for encounters with turtles (Cazabon-Mannette et al., 2017), for reef water clarity (Farr et al., 2017), and for site access (Chae et al., 2017; Arin and Kramer, 2002).

Cazabon-Mannette et al. (2017) used a contingent valuation method to estimate the WTP amount for international divers in Tobago. They estimated that the WTP for a first turtle encounter was USD62 per two tank dive and USD31 per two-tank dive for turtle conservation. This latter value reflects the cultural services in the ecosystem services framework.

There is evidence that the public place a value on the conservation of biodiversity and species protection. Further investigations in the value of biodiversity and species protection are likely to bring valuable insights on sites and species that are deemed most valuable to both the Australian public and international visitors. However, based on the reviewed literature the non-market value associated with marine species and a fishing site will be influenced by the species type and also by type of visitors or respondents.

Key points
Australians and international visitors place a value on the protection of conservation areas, biodiversity and species protection. The estimated values are influenced by species, site and survey respondent type (local or tourist).

5.3.5 Fish welfare – *cultural ecosystems service*

In aquaculture, just like in livestock farming, there are growing public concerns and scrutiny on fish welfare. This is a form of a non-use value motivated by people's philosophical motives. This is a form of cultural ecosystem service within the ecosystem services framework. However, there is a paucity of national and international non-market valuation studies on fish welfare. In the international space, there is evidence of consumer WTP for improved fish welfare (Grimsrud et al., 2013; Solgaard and Yang, 2011) and sustainable seafood (Zander and Feucht, 2018). However, this non-market value is usually not captured in market pricing.

Grimsrud et al. (2013) investigated households' WTP for improvements in fish welfare through breeding programs for farmed Atlantic salmon in Norway. They estimated that the average annual household WTP for improved resistance to diseases was NOK613 and NOK951[14] for resistance to lice. In Denmark, Solgaard and Yang (2011) undertook a contingent valuation study for WTP for fish welfare and found that Danish consumers place a 25% average premium for fish welfare.

While wild capture fish welfare has been covered in previous studies (e.g. Diggles et al., 2011; Capozzelli et al., 2020), there still a lack of information on the actual willingness to pay for improvements in the welfare of wild fish. By comparison, the ethical debate in aquaculture has focussed on fish welfare while in wild capture, the focus has largely been around environmental impacts, the interaction of fishing gear on fish habitats, the status of wild fish populations, and incidental damage to non-target fishes (Huntingford and Kadri, 2009).

There is still some basic evidence of potential willingness to pay for improvements in welfare of wild-catch fish. Brayden et al. (2018) studied consumer preferences for seafood attributes of wild capture and aquaculture in the US. They found that consumers were willing to pay more for fish that is harvested in the wild, locally produced and certified as organic. A choice experiment study in Norway by Olesen et al. (2010) found that consumers were willing to pay a premium of 2 euros for farmed organic and welfare-labelled salmon. Given the findings from Brayden et al., (2018) and Olesen et a. (2010), it is evident that seafood consumers do place a premium on fish attributes and it is likely that they will have a premium for wild-catch fish that is harvested under improved welfare arrangements. However, there is an apparent lack of data on the value of the premium placed on wild-catch fish.

[14] Where NOK is the Norwegian Krone

Key points

There is international evidence of positive WTP for farmed fish welfare. However, no Australian studies were found to have investigated the non-market value placed on fish welfare from Australian aquaculture or from wild-catch fishing methods.

Previous studies indicate that seafood consumers prefer fish that is harvested in the wild and they place a premium seafood with better fish welfare attributes. However, there is a gap in the value of the premium consumers might place on improved welfare outcomes for wild-catch fish.

5.3.6 Value of fish/fishing sites to indigenous communities – *cultural and provisioning ecosystem services*

In Australia fresh and saltwater fisheries often have a cultural significance to Indigenous Australian communities. These values are typically not captured in market interactions or even in the WTP studies for recreational fishing. The Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS, 2018) states that a non-indigenous recreational fisher does not get the same cultural benefits from fishing as an indigenous fisher. The indigenous fisher thinks in terms of a connection to their ancestors and the Country, and the fishing site and activity are central to their culture and identity (AIATSIS, 2018). According to Voyer et al. (2016) coastal fishing has several wellbeing benefits to indigenous Australians, such as cultural and social connection, education and traditional knowledge, cultural heritage and community identity, and leisure and recreation.

Another FRDC project (No. 2018-068) provides a detailed review of the "value of fish to indigenous communities" (Coglan et al., 2019). Coglan et al., (2019) posits that the standard economic valuation methods may not be suitable for addressing cultural and customary values. However, they state that indigenous values have been estimated for other sectors, for example, by McDaniels and Trousdale (2005) on the impact of resource losses to indigenous Canadian communities. McDaniels and Trousdale (2005) used a multi-criteria analysis and found that the resource loss due to petroleum exploration and associated land-use changes will lead to a loss of over $2.6 million per year to the Metis community in Canada. Coglan et al. (2019) state that the other methods which could be used for valuing non-market values to indigenous Australians include replacement costs, but such approaches only capture a part of the value.

Key points

Indigenous Australian communities tend to have non-market values for fishing and fishing sites that are not captured by current valuation methods. These values include cultural connection to the fishing activity or to the site.

Conservative non-market values could be estimated using asset replacement methods, but the estimated values would likely to be underestimates.

5.3.7 Landscape and local amenity – *cultural service*

In the case of aquaculture, there are potential negative externalities for nearby land users. The impact of aquaculture farms on humans include noise, odour and visual disamenity effects (Victorian Fisheries Authority, 2008). For example, equipment used to scare predatory birds can lead to neighbourhood noise pollution, particularly where the farm is located near a residential area or there are other site users. The cost of noise, odour and visual amenity can be estimated using a hedonic property valuation study. Such a study will provide information on the estimated cost of noise, odour and/or visual disamenity through property price differences. While there are several studies on economic impacts of noise and air pollution, and visual amenities (e.g. Nelson (2004); Cohen and Coughlin (2008)) these do not extend to disamenities directly linked to aquaculture operations.

Key points

Aquaculture operations located near residential and other land uses have potential negative landscape and local impacts through noise, air and visual disamenities. While these externalities are acknowledged in best practice management guidelines, there is a dearth of data on the values associated with these disamenities from aquaculture operations.

The value of these negative externalities can be estimated using hedonic property valuation studies and stated preference surveys.

5.3.8 Social benefits

Investments in Fisheries RD&E often lead to important social impacts for the fishing industry and community at large. Some of these social benefits overlap with the non-market benefits outlined in the preceding sub-sections e.g. cultural and provisioning benefits associated with indigenous community fishing are also social benefits. This section is therefore focused on three broad social benefit types i.e. social benefits from training and education, creating a social licence to operate for businesses, and contributions to individual and community wellbeing.

Education & Training

At times FRDC invests in RD&E through support for research and postgraduate training, and general industry capacity building initiatives. Key benefits of such investments include upskilling individuals and enhancing industry capacity to exploit opportunities as they arise. While these benefits are apparent, measuring them in monetary terms is often a challenge. Previous research on return on investment in education indicates that there are several benefits from research training and education. These include benefits to the scholarship recipients, their employer and the society at large. Benefits for individuals can be measured through higher salaries (Holbrook et al., 2009). While there is a scarcity of studies on the return to tertiary education such as masters or doctoral degrees, Mariotti and Meinecke (2011) estimated that the return to education in Australia was 8.1% for Australian school graduates. In the UK, Blundell et al. (1999) found that the average annual return to a first degree ranged from 5-8% for men and 10-13% for women compared to an A-level qualification. Trostel (2007) estimated that compared to a high school qualification there were premiums of US$51,781 for a Bachelor's degree, US$10,323 for a master's degree and $70,714 for professional and doctorate degrees in 2005 in the US. However, these premiums are sensitive to the supply of post-graduate degree holders in the market and the specific subject areas / professions. Additionally, the returns to individuals working in the private sector are higher than those in the public/government sector (Psacharopoulos, 1994). The concept of rate of return on investment in further education is similar to any other investments and it requires an assessment of costs (expenditure on educational training) and benefits (additional salary).

Employers' WTP more for postgraduates suggests that they expect gains in productivity and innovation (Holbrook et al., 2009). International research indicates that employees with research training have been found to bring important skill sets to their organisation which help achieve some productivity gains. For example, Blundell et al., (1999) found that manufacturing factories with highly skilled manpower experienced higher labour productivity and adopted more sophisticated technology more smoothly.[15] Thus, there is evidence that employers generally gain from investment in further education and training. While there is evidence of clear benefits to employers, there is a paucity of data on the actual magnitude of these benefits. Blundell et al., (1999) points out that it is relatively more difficult to measure the benefits to firms compared to individuals because it is more difficult to get data on productivity, competitiveness, and profitability of firms and link changes to investment in further education and training.

Social impacts from employees with higher degrees include increased economy-wide productivity spill-overs and increased tax revenues for the government (Blagg and Blom, 2018). Trostel (2007) found that

[15] Other studies which suggest positive gains to the employers from research training or further education include Nielsen (2007), Salter and Martin (2001).

employees with doctorate degrees paid over 4.4 times as much in state income taxes in present value terms compared to school graduates.[16] As a benchmark, the estimated return on investment from training in research can, therefore, be compared with the federal government's stated efficiency dividend rates to provide an indication of the fisheries RD&E. The 2020/21 efficiency divided is currently set at 2% (Australian Chamber of Commerce, 2019).[17]

Social Licence to Operate for Australian Fishers

A social licence to operate benefit may be captured through projects that contribute to market access and/or market share, or industries/producers that are sanctioned by the public to continue to operate due to their contribution and their lack of negative environmental or community impacts. Projects that may contribute to social licence to operate include those that promote trust, credibility, and legitimacy. Market valuation approaches can be used to estimate the value of operational continuity and continued market access.

Health & Wellbeing

Training and education of fishing personnel and any improvements to the ability to access new markets or retain market share can lead to improvements in income stability and consequently enhanced health and wellbeing. For example, a study on graziers in Australia found that innovative farmers who practised regenerative agriculture reported higher self-efficacy – the confidence to be able to manage different farm aspects. These farmers were found to be as profitable and at times more profitable, and they had greater income stability compared to other farmers (Ogilvy et al., 2018). Both self-efficacy and increased incomes are key determinants of wellbeing and they can be achieved through training and education. Wellbeing is generally measured using subjective indices of life satisfaction such as the Australian Unity Personal Wellbeing index, World Health Organisation- Five Wellbeing Index (WHO-5), and US EPA Human Wellbeing Index (HWBI) (Cummings et al., 2008, Topp et al., 2015). The Australian Unity Personal Wellbeing index has been used to track how satisfied people in Australia are with their lives as a whole including future security, financial situation, and standard of living, among others (Cummings et al., 2008, Capic et al., 2017). These indices provide an overall score of wellbeing and there is limited information on how the scores from these indices could be translated into monetary terms. Such an undertaking is a challenging task. Previous WTP studies have been undertaken using contingent valuation studies to elicit individuals' WTP for a quality-adjusted life year (QALY). Using this approach, Mavrodi et al. (2017) found positive WTP for health gain of 2,629 Euros in Greece.

In Australia, the value of a statistical life has been used to estimate the monetary value of improvements in health, increases in wellbeing and avoided deaths. The value of a statistical life (VASL) is generally assumed to be the life of a young adult with at least 40 years of life ahead. Abelson (2007), estimated that the value of a statistical life ranges from $3 to $15 million but the most credible value is $3.5 million. This amount is usually discounted over a 40-year period to estimate the value of a statistical life year. Agtrans Research (2019) used a conservative value of $150,000 and the Department of Prime Minister and Cabinet (2014) recommends $182,000 as the value of a statistical life year. Both the Abelson (2007) and the guidelines from the Department of Prime Minister and Cabinet may be used to estimate the health and wellbeing related outcomes. There are, however, opportunities to invest in bespoke WTP studies to investigate the health and wellbeing outcomes from fisheries RD&E projects.

Community Spill-overs

Investment in fisheries RD&E has important spill-over community and regional benefits. Such benefits stem from fishing industry investment, input, product supply chain and employment generation. However, these benefits are challenging to estimate as there is usually limited information on how to objectively assign benefit attribution. Direct and indirect impacts from large projects or changes in industry policies may be

[16] Based on 3% discount rate and an average retirement age of 75.

[17] An efficiency dividend is the annual efficiency dividend that reduces entity budgets each year in anticipation of efficiencies being found.

estimated using economic impact methodologies such as the input-output framework and the computable general equilibrium (CGE). The input-output framework relies on the use of multipliers to calculate direct and indirect economic impacts including impacts on jobs. However, the ABS cautions against their use as they are generally not suitable for use in small regions and have some inherent limitations such as the lack of supply-side constraints and the assumption of fixed prices (ABS, 2012).

CGE models may be used to estimate state and national impacts of major economic projects such as those related to infrastructure investments and changes in industry policies. These models have been used widely where inter-industry, inter-regional or economy-wide impacts from a policy are expected (e.g. Neill et al., (2019) used the CGE to estimate impacts of the WA's domestic gas reservation policy and Murphy (2016) on effects on consumer welfare from corporate tax cut). While these models could be applied for key policy changes affecting the fishing industry, they may not always be appropriate for quantifying benefits from several small RD&E projects funded by the FRDC.

Key points

Postgraduate training and education benefits lead to benefits to the scholarship recipient through higher wages, to the industry through gains in productivity and innovation, and to society in general through higher tax revenues.

Social licence to operate is an important industry benefit. It can be achieved through investment in projects that support access to new markets, and those that helps increase or maintain market share. Social licence to operate benefits for individual operators should those associated with practices that are over and above regulatory requirements. These benefits can be estimate using market valuation approaches that rely on price and volumes sold.

Another important social benefit is personal and community wellbeing through reductions in stress from income variability and depressed sense of security. Existing wellbeing measures rely on subjective wellbeing indices with limited translation to monetary impacts. However, non-market valuation techniques such as contingent valuation and value of a statistical life have been applied to estimate people's WTP for gains in their health, wellbeing and avoided deaths.

Other social benefits may be in the form regional economic impacts and these can be estimated using economic impact approaches such as the input-output and computable general equilibrium models.

Overall, there is lack of economic values of wellbeing impacts attributable to the fishing industry.

5.4 Key Findings

Evidence from the literature indicates that there are many non-market benefits from fisheries RD&E that could be valued in monetary terms. However, there are also gaps in data and these gaps could be used to prioritise future valuation studies so that more of the non-market and social benefits can be included in future cost-benefit analysis evaluation.

Eight major categories of non-market and social benefits were identified. These include:

- Value of fisher satisfaction,
- Recreational value of fishing,
- Blue carbon,
- Biodiversity and species protection,
- Fish welfare,
- Value of fish/fishing to indigenous communities,
- Landscape and local amenity, and
- Social benefits

An overview of the available literature and its suitability to provide quantitative estimates to inform fisheries RD&E projects evaluation is provided for each of the eight categories below.

Value of fisher satisfaction

The literature review indicates that recreational fisher satisfaction is an important outcome from engaging in a recreation activity. Recreational anglers derive utility from the fishing experience and their utility is a function of the fishing site, catch rates, catch size, species, angler's age, and accessibility by boat. However, there is limited understanding of the impact of satisfaction on the value of a fishing experience. A contingent valuation or choice modelling approach could be used to derive a WTP amount for fisher satisfaction. Such a study should seek to provide insights on the WTP values and identify the key attributes driving fisher experience in an Australian context.

Recreational value of fishing

Several Australian studies have been undertaken to estimate the value of recreational fishing and the results from these studies can be used to inform a benefits-transfer valuation approach. Most of the Australian studies have used the travel cost model to estimate consumer surplus values for a recreational fishing trip. A few studies have used the contingent valuation method to estimate WTP for a fishing trip. Where there are sufficient resources and time, bespoke travel cost modelling could be undertaken to provide robust and site specifics values, however, there are available data that could be used in a benefit-transfer exercise.

Blue carbon sequestration

FRDC's investment in better management and protection of ecosystems in fishing areas results in better health for aquatic plants such as mangroves, saltmarsh and seaweed. These plants provide carbon sequestration benefits. While there are variations in the estimated carbon sequestration rates and carbon prices, previous studies indicated a significant market and non-market benefit from increasing blue carbon sequestration and storage.

There is an opportunity for FRDC to demonstrate its contribution to the mitigation of greenhouse gas through regulation ecosystem services from fisheries. An investigation that covers biophysical estimates of carbon mitigation volumes and the value of the avoided pollution will provide important information on how research funded by FRDC may be contributing to direct or indirect mitigation of greenhouse gas pollution.

Biodiversity and species protection

Biodiversity is important for the future of sustainability of natural fisheries used for both recreational and commercial purposes. There are several national and international studies on value of biodiversity and species protection. However, the estimated values are influenced by the species, site and the survey respondent type (e.g. local/tourist). Therefore, while there is literature on the value biodiversity and species protection the estimated values should be used cautiously to ensure that there are similarities between the original study and context for which the analysts wishes to use the estimated values. In some cases, where resources are available it will be beneficial to undertake species or site-specific non-market valuation studies to best capture the value attached to a specific fish/site type. Such a bespoke studies will provide estimated values that take into account attributes that are site and user specific.

Fish welfare

There is international evidence of positive WTP for farmed fish welfare. However, no Australian studies were found to have investigated the non-market value placed on fish welfare from Australian aquaculture or from wild-catch fishing methods. There is a need to undertake an Australian study to provide insights on the magnitudes of WTP amounts for farmed fish welfare. There is also a gap in the value of the premium that consumers might place on improved welfare outcomes for wild capture fish.

Value of fish/fishing sites to indigenous communities

Estimating the economic value of fish or fishing sites to indigenous communities is a challenging task. However, these communities have significant cultural and heritage values for fishing activities and sites. Conservative estimates could be estimated using asset replacement methods, but these methods will provide underestimated values and may not be suitable where the value is attached to a specific site and not to the fish or the fishing activity.

Landscape and local amenity

FRDC contribution to investments in better planning and construction of aquaculture farms helps in the mitigation or avoidance of impacts associated with negative landscape effects. Reductions in noise and odour pollution and improvements in visual amenity are part of the cultural ecosystem service under the CICES framework. Estimated benefits of better planning could be investigated using stated preference surveys and where the farms are already located near residential areas a hedonic property valuation study could be used to capture the effect of an aquaculture farm on the local real estate market.

Social benefits

FRDC's investment can lead to important social benefits including wage increases, industry productivity, increased tax revenues, improvements in health and wellbeing, and regional economic impacts. There are limited studies on the impact of fisheries RD&E investment on health and wellbeing. However, generic methods such as the value of a statistical life have been used. Where appropriate the economic impact models can also be used to estimate the regional benefits of FRDC's investments. In future, further research on how specific projects contribute to improvements in health and wellbeing will provide valuable data for use in cost-benefit analysis studies.

Conclusions

The main areas requiring further benefit estimation studies include:

- Value of fisher satisfaction,
- Contribution of fish habitat to carbon sequestration and storage,
- Willingness to pay for fish welfare, particularly farmed fish,
- Industry stakeholders' WTP for improvements to human health and wellbeing, and
- Social equity and maintained or enhanced social capital for fishers and fishing communities.

While there are many published studies on the value of a recreational fishing trip and WTP for biodiversity and species protection, there are still opportunities for FRDC to contribute. These contributions could be through funding of research on the value of recreational fishing at specific and major fishing sites in Australia or the WTP for specific Australian fish species.

6. Linking Available Literature to Past Impacts of FRDC RD&E Impacts

The following section aims to identify the useful links between the environmental and social impacts identified from past FRDC RD&E investments and the existing body of non-market valuation literature.

6.1 Environmental Impacts

The key environmental impacts produced by FRDC RD&E investments may be linked to a number of the types of non-market values identified through the literature review (see Section 5.3).

Improved water quality

Water quality (freshwater and/or seawater) can be a somewhat ambiguous term. Generally, the term water quality is used to refer to the physical, chemical and biological characteristics of water (Government of Western Australia, 2020). Improved water quality driven by, for example, reduced chemical use, may be associated with the following types of non-market impacts:

- Value of fisher satisfaction through its contribution to improved amenity of fishing sites, increased biodiversity, and improved fish health,
- Recreational value of fishing also through its contribution to improved amenity of fishing sites, increased biodiversity, and improved fish health, and
- Fish welfare through the direct link between water quality and aquatic/marine animal health.

Fisher satisfaction, recreational value, and fish welfare may be considered 'use' values for water. However, improved water quality also may have non-use related values. For example, people may value the existence of a 'clean' water source for environmental and social reasons regardless of whether they ever intend to visit and/or use a particular water source.

Improved aquatic/marine animal health/wellbeing

Aquatic and marine animal health and wellbeing could be linked to:

- Fish welfare, and
- Biodiversity and species protection as improved animal health may contribute to maintained or improved biodiversity (species diversity and abundance).

Improved ecosystem sustainability and health

Improved ecosystems may be connected to:

- Value of fisher satisfaction through its contribution to improved amenity of fishing sites, increased biodiversity, and improved fish health,
- Recreational value of fishing also through its contribution to improved amenity of fishing sites, increased biodiversity, and improved fish health,
- Blue carbon as a result of increased aquatic plant life and protection of key carbon sequestration environments such as mangroves,
- Biodiversity and species protection,
- Fish welfare through the direct link between water quality and aquatic/marine animal health, and
- Value of fish/fishing sites to indigenous communities.

Ecosystems also may have non-use value. For example, people may derive value from the satisfaction of preserving an ecosystem for future generations (known as bequest value).

Increased biodiversity (species diversity and abundance)

Increased biodiversity impacts link directly to biodiversity and species protection values in the non-market valuation literature. Biodiversity values are influenced by species, site, and respondent type and it may be difficult to apply findings specific to one species or location to another (through an economic valuation method known as benefit transfer). Increased biodiversity also may be linked to:

- Value of fisher satisfaction, and
- Recreational value of fishing.

Increased environmental sustainability of wild-catch fisheries and aquaculture

Increased environmental sustainability for wild-catch fisheries and aquaculture tends to refer to the adoption of practices that reduce, minimise, or eliminate environmental degradation during commercial fishing/ aquaculture operations. Increased environmental sustainability may be associated with:

- Biodiversity and species protection, and
- Blue carbon.

However, reduced or avoided degradation of marine and aquatic environments/ habitats also may have non-use values.

Improved conservation of aquatic/ marine assets

Improved conservation, for example, improving commercial fishing practices and/or equipment to reduce environmental damage and/or by-catch, may be linked to:

- Biodiversity and species protection, and
- Blue carbon.

Improved environmental and natural resource management for wild-catch fisheries and aquaculture

Similar to improved ecosystem health, improved management of aquatic and marine environments and natural resources has the potential to be linked to:

- Value of fisher satisfaction through its contribution to improved amenity of fishing sites, increased biodiversity, and improved fish health,
- Recreational value of fishing also through its contribution to improved amenity of fishing sites, increased biodiversity, and improved fish health,
- Blue carbon as a result of increased aquatic plant life and protection of key carbon sequestration environments such as mangroves,
- Biodiversity and species protection,
- Fish welfare through the direct link between water quality and aquatic/marine animal health, and
- Value of fish/fishing sites to indigenous communities.

Reduced noise and/or odours from fisheries/ aquaculture operations

Reduced noise and/or odours from fisheries or aquaculture operations falls under regulation and maintenance services and cultural ecosystems service in the CICES framework. It is possible that, in specific areas, such impacts may be associated with the value of fisher satisfaction. In other cases, e.g. in the case of aquaculture farms, the impact may be associated with landscape and local amenity effects which falls under the cultural ecosystem services within the CICES framework.

Aquatic/ marine species conservation status maintained or increased

Improved conservation of aquatic and marine species is linked to biodiversity and species protection values.

Aquatic/ marine species stock sustainability maintained or increased (particularly commercially harvested, wild-catch fish stocks)

Stock sustainability is linked to biodiversity and species protection values. However, such impacts also may be linked indirectly to improved ecosystems and therefore other non-market values such as blue carbon sequestration.

Reduced risk of pests & diseases entry and/or establishment Australia

Reduced risk of entry and/or establishment of exotic pests and diseases as an environmental impact is primarily linked to biodiversity and species protection values but may also be associated with fish welfare. However, it is worth noting that, where there is a risk to species that are fished or farmed commercially, market mechanisms may also be used to value potential impacts, although such methods are likely to underestimate the total value of the impacts.

Table 3 summarises the key environmental impacts identified for FRDC RD&E investments, how the impacts may be categorised under the CICES framework, and the types of non-market values reported in existing literature that may potentially be linked to the environmental impacts. This table may be used to help identify studies within the fisheries non-market values database accompanying this report to support future impact assessments of FRDC RD&E investments. For example, if an investment was subjected to impact assessment and was found to contribute to improved conservation of a particular marine species, the analyst could use Table 3 to identify that such an impact would be classified as regulating and maintenance ecosystems services under the CICES framework and that the impact may be linked to biodiversity and species protection values within existing non-market valuation literature. The analyst then could search the non-market value studies database for valuation studies completed for similar species and/or locations that could, potentially, be used to value the impact utilising a benefit transfer approach[18].

Table 3: Summary of Impact Assessments of FRDC Investments Undertaken by Agtrans

Environmental Impact Types	**Ecoservices Type (CICES)**	**Potential Linkage to Non-market Valuation Literature**
Improved water quality	Regulating and maintenance	• Value of fisher satisfaction • Recreational value of fishing • Fish welfare
Improved aquatic/ marine animal health/ wellbeing/ welfare	Cultural and/or provisioning	• Biodiversity and species protection • Fish welfare
Improved ecosystem sustainability and health	Regulating and maintenance	• Value of fisher satisfaction • Recreational value of fishing • Blue carbon • Biodiversity and species protection • Fish welfare • Value of fish/fishing sites to indigenous communities
Increased biodiversity (species diversity and abundance)	Regulating and maintenance	• Biodiversity and species protection • Value of fisher satisfaction • Recreational value of fishing

[18] Non-market valuation approaches, such as benefit transfer, are discussed further in Section 7 of this report.

Increased environmental sustainability of wild-catch fisheries and aquaculture	Regulating and maintenance	• Blue carbon • Biodiversity and species protection
Improved conservation of aquatic/ marine assets	Regulating and maintenance	• Blue carbon • Biodiversity and species protection
Improved environmental and natural resource management for wild-catch fisheries and aquaculture	Regulating and maintenance	• Value of fisher satisfaction • Recreational value of fishing • Blue carbon • Biodiversity and species protection • Fish welfare • Value of fish/fishing sites to indigenous communities
Reduced noise and/or odours from fisheries/ aquaculture operations[19]	Cultural and/or Regulating and maintenance	• Value of fisher satisfaction • Landscape and local amenity
Aquatic/ marine species conservation status maintained or increased	Regulating and maintenance	• Biodiversity and species protection
Aquatic/ marine species stock sustainability maintained or increased (particularly commercially harvested, wild-catch fish stocks)	Regulating and maintenance	• Blue carbon • Biodiversity and species protection
Reduced risk of pests & diseases entry and/or establishment Australia	Regulating and maintenance	• Biodiversity and species protection • Fish welfare

6.2 Social Impacts

Some social impacts may be valued using market mechanisms. For example, as described in 5.3.8, the benefits of increased capacity to an individual may be measured through higher salaries/earning potential and benefits to businesses may be analysed through the return on investment in training and capacity building activities. Also, social licence to operate may be captured through reduced risks to industry profitability or maintained access to key markets. Key social impacts that may require the application of non-market values include:

- Increased health and/or wellbeing for fisheries and/or aquaculture producers (increased human wellbeing) – typically estimated by application of the value of a statistical life,
- Maintained or improved amenity – in terms of fishing and aquaculture, amenity impacts may be linked to environmental values such as:
    - Landscape and local amenity
    - Value of fisher satisfaction,
    - Recreational value of fishing, and
    - Value of fish/fishing sites to indigenous communities.

[19] Where aquaculture farms are located close to residential developments, this impact also includes a 'cultural ecosystem service' in the form of amenity values. This impact can be estimated using a hedonic property valuation method.

However, improved amenity of environmental assets such as marine/aquatic ecosystems is not necessarily restricted to fishers and indigenous peoples.

- Increased social equity and maintained or enhanced social capital – as noted previously (Section 5.3.8) there was an absence of existing literature associated with increased social equity and maintained/enhanced social capital linked to fisheries RD&E.

7. Review of Non-Market Valuation Methods

7.1 Introduction

Valuation aims to estimate economic values for non-market goods and services. To place an economic value on a non-market good or service, the various components that make up its total economic value (TEV) need to be identified. For environmental goods and services, the TEV consists of 'use values' and 'non-use values'.

Use value (UV) relates to the present or future use of a particular environmental asset by individuals. UV can be further subdivided into 'direct use' values and 'indirect use' values. Direct use values are derived from the actual use of a resource either in a consumptive way or a non-consumptive way (e.g. timber in forests, recreation, fishing); indirect use values refer to the benefits derived from ecosystem services (e.g. watershed protection or carbon sequestration)

Non-use values (NUV) are associated with benefits derived from the knowledge that a natural resource, such as a marine species or ecosystem, is maintained. By definition, such values are not associated with the use of the resource or the tangible benefits derived from its use. NUV also can be subdivided into two parts. First, there are 'existence' values, that are not connected to the real or potential use of the good, but, reflect a value that is inherent in the fact that it will continue to exist independently from any possible present or future use by individuals. Secondly, 'bequest' values (also known as altruism values) are associated with the benefits the individuals derive from the awareness that future generations may benefit from the use of the resource. A separate category is made up by 'option' values attributed by individuals based on the knowledge that a resource will be available for future use. Thus, it can be considered like an assurance that a resource will be able to supply benefits in the future (Abdullah, Markandya, & Nunes, 2011). Figure 2 shows a summary of the components that make up the TEV of goods and services.

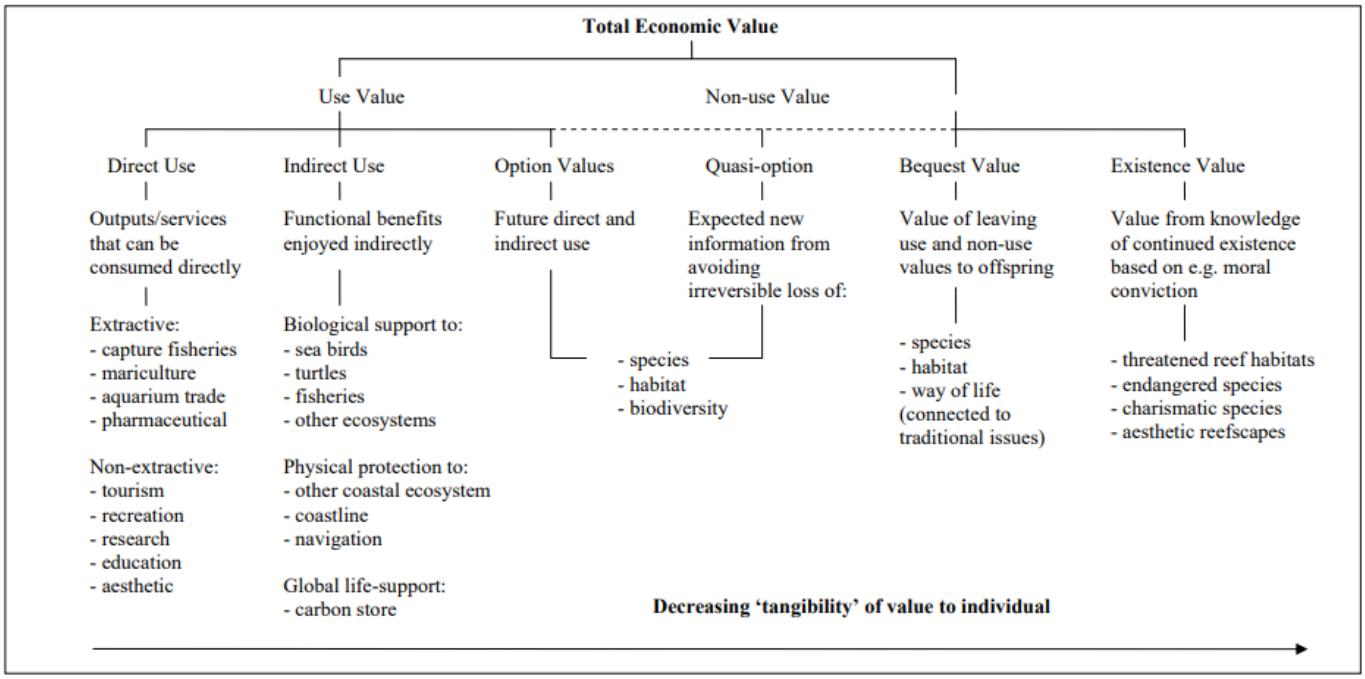

Figure 2: Components of Total Economic Value

Source: Tapsuwan, Ranjan, McFarlane, & Elmahdi (2009)

Various methods have been developed to estimate the components of the TEV for non-market goods and services such as environmental assets. Some valuation methods are more suitable for certain types of values than others and each method has its own pros and cons. The following section briefly describes

current valuation methods that may be useful for future studies to fill the information gaps identified for the valuation of impacts from FRDC RD&E investments.

7.2 Economic Valuation Methods

There are two main groups of economic valuation methods: revealed preferences methods (RP) and stated preference methods (SP). Revealed preference methods are based on actual market behaviour of users of ecosystem goods and services. However, their applicability is limited to the use values of ecosystem goods and services. Stated preference methods can be applied to both use and non-use values of ecosystem goods and services where suitable data are available. However, their main disadvantages are that they are based on hypothetical situations and their application is complex and resource consuming (Plan Bleu, 2015). Figure 3 shows a summary of potential valuation methods for use and non-use values utilising RP and SP methods.

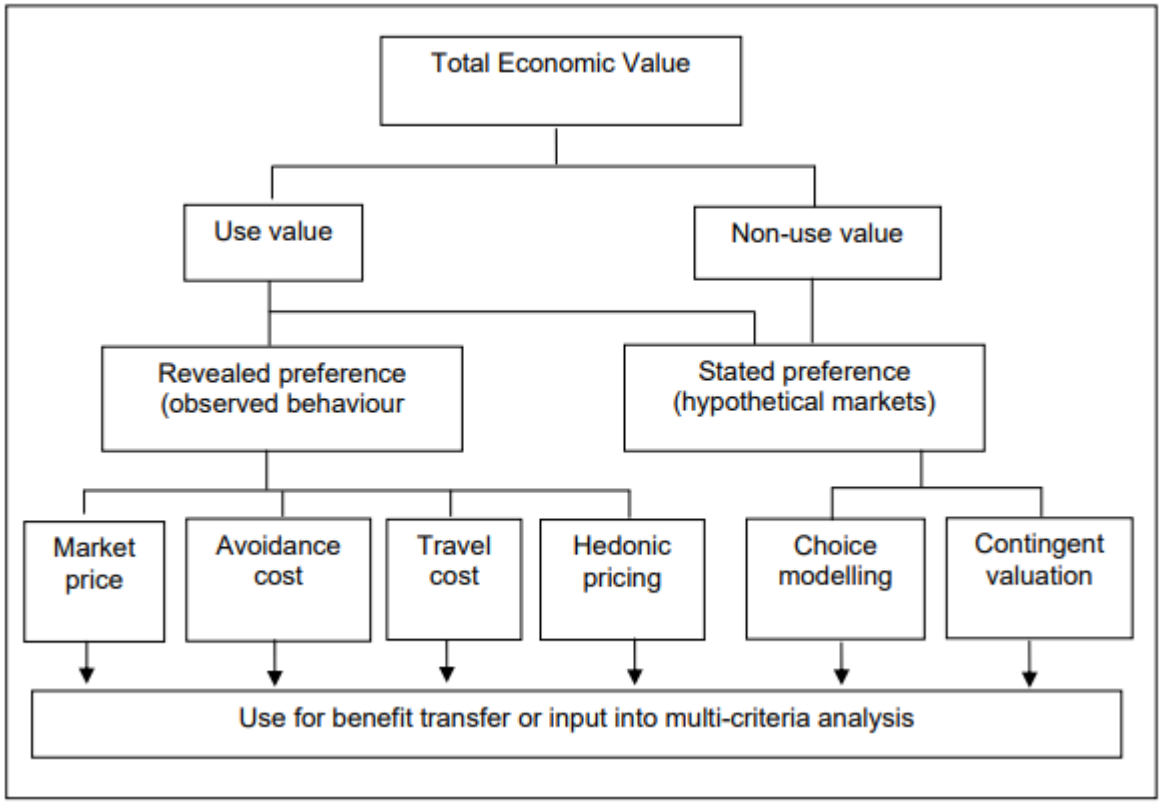

Figure 3: Economic Valuation Methods for Use and Non-Use Values

Source: Tapsuwan et. al. (2009)

A wide range of literature exists on the methods and application of economic valuation techniques and the Australian Government Productivity Commission has produced a Guide to Non-Market Valuation that can be found at: https://www.pc.gov.au/research/supporting/non-market-valuation/non-market-valuation.pdf.

The following sections provide a summary of the various RP and SP methods and their key strengths and weaknesses. This material is taken from the 'Comparison of Economic Valuation Methods' fact sheet compiled by Plan Bleu as part of the Mediterranean Action Plan for the United Nations Environment Program. Further detail may be found at: https://planbleu.org/sites/default/files/upload/files/FactSheets_methods_EN.pdf

7.2.1 Revealed Preference Methods

Market Price

The market price method estimates the economic value of ecosystem goods or services that are bought and sold in markets. The market price method can be used to value changes in either the quantity or

quality of a good or service and uses standard economic techniques for measuring the economic benefits from marketed goods and services, based on the quantity people purchase at different prices, and the quantity supplied at different prices.

Strengths:

- People's values are likely to be well-defined as it reflects an individual willingness to pay for costs and benefits of goods or services that are bought and sold in markets.
- Data are relatively easy to obtain.
- Uses observed data of actual consumer preferences.
- Uses standard, accepted economic techniques.

Weaknesses:

- Market data only are available for a limited number of goods and services.
- True economic value of goods or services may not be fully reflected in market transactions.
- Seasonal variations and other effects on price must be considered.
- Cannot be easily used to measure the value of larger scale changes that are likely to affect the supply of or demand for a good or service.
- Usually, the market price method does not deduct the market value of other resources used to bring ecosystem products to market, and thus may overstate benefits.

Cost based methods

Cost based methods, including damage cost avoided, replacement cost, and substitute cost methods, are related methods that estimate values of ecosystem goods and services based on either the costs of avoiding damages due to lost services, the cost of replacing environmental assets, or the cost of providing substitute goods or services.

The damage cost avoided method uses either the value of property protected, or the cost of actions taken to avoid damages, as a measure of the benefits provided by an ecosystem. The replacement cost method uses the cost of replacing an ecosystem or its goods and services as an estimate of the value of the ecosystem or its goods and services. Similarly, the substitute cost method uses the cost of providing substitutes for an ecosystem or its goods and services as an estimate of the value of the ecosystem or its goods and services.

Strengths:

- Rough indicator of economic value, subject to data constraints and the degree of similarity or substitutability between related goods or services.
- Easier to measure the costs of producing benefits than the benefits themselves, when goods, services, and benefits are non-marketed.
- Less data- and resource- intensive.
- Provide surrogate measures of value that are as consistent with the economic concept of use value for goods or services which may be difficult to value by other means.

Weaknesses:

- Expenditures to repair damages or to replace ecosystem goods and services are not always measures of the benefits provided.
- Do not consider social preferences for ecosystem goods and services.
- In certain cases, the cost of a protective action may actually exceed the benefits to society.
- Substitute goods or services are unlikely to provide the same types of benefits as the natural resource.
- Goods or services being replaced probably represent only a portion of the full range of goods and services provided by the natural resource.

Travel cost

The travel cost method is used to estimate the value of recreational benefits generated by ecosystems. It assumes that the value of the site or its recreational services is reflected in how much people are willing to pay to get there. There are several varieties of the travel cost method: simple zonal travel cost method (using mostly secondary data), individual travel cost method (using a more detailed survey of visitors and statistical analysis), and random utility travel cost method (using survey and other data, and statistical techniques). The basic premise of the travel cost method is that the time and travel cost expenses that people incur to visit a site represent the value of access to the site. Thus, peoples' willingness to pay to visit the site can be estimated based on the number of trips that they make at different travel costs. This is analogous to estimating peoples' willingness to pay for a marketed good based on the quantity demanded at different prices.

Strengths:

- Similar to more conventional approaches to estimate economic values based on market prices.
- Based on actual behaviour, and therefore more reliable that methods based on hypothetical behaviour of the respondents.
- On-site surveys provide opportunities for large sample sizes.
- Results are relatively easy to interpret and explain.
- Relatively inexpensive to apply.

Weaknesses:

- Assumption that people respond to changes in travel costs the same way that they would respond to changes in admission price might not always be true.
- Limited in its scope of application because it requires user participation.
- Standard approaches provide information about current conditions, but not about gains or losses from anticipated changes in resource conditions.
- The simplest travel cost models assume that individuals take a trip for a single purpose.
- The availability of substitute sites will affect values.
- The method can underestimate the value for people living next to the valued site.
- Measuring the opportunity cost of time can be problematic.
- It cannot be used to measure non-use values.

Hedonic pricing

The hedonic pricing method (HP) relies on market transactions for differentiated goods to estimate the economic benefits or costs associated with environmental quality. The basic premise of the HP method is that the price of a marketed good is related to its characteristics, or the services it provides. For example, the price of a house is related to the characteristics of the house and property itself, the characteristics of the neighbourhood and community, and environmental characteristics. Thus, if non-environmental factors are controlled for, then any remaining differences in price can be attributed to differences in environmental quality. For example, if all characteristics of houses and neighbourhoods throughout an area were the same, except for the level of air pollution, then houses with better air quality would cost more. This higher price reflects the value of cleaner air to people who purchase houses in the area.

Strengths:

- Can be used to estimate values based on actual choices.
- Property markets are relatively efficient in responding to information, so can be good indications of value.
- The method is versatile and can be adapted to consider several possible interactions between market goods and environmental quality.
- Property records are typically very reliable.

Weaknesses:

- Scope of environmental benefits that can be measured is mainly limited to things that are related to housing prices.
- Only captures people willingness to pay for perceived differences in environmental attributes, and their direct consequences.
- Assumes that people have the opportunity to select the combination of features they prefer, given their income.
- Results depend heavily on model specification.
- Large amounts of data must be gathered and manipulated.
- Relatively complex to implement and interpret, requiring a high degree of statistical expertise.
- Time and expense to carry out an application depends on the availability and accessibility of data.

7.2.2 Stated Preference Methods

Choice Modelling

The choice experiment method is a questionnaire-based technique that seeks to discover individual preferences for simultaneous changes in the attributes that comprise an environmental good or service. Stated preference methods are the only methods that can assess non-use values of ecosystems but can also be used to estimate use values generated by the ecosystems. In addition, due to their hypothetical nature, these methods can be used to assess social preferences ex-ante, i.e., for changes that have not already taken place. The basic premise of the choice experiment is that an environmental good or service can be decomposed in a bundle of attributes or features and that individuals are sensitive to changes in these attributes. Therefore, individuals are asked through a survey to state their willingness to pay to undergo these changes.

Strengths:

- They are the only available methods to estimate non-use values.
- They can also be employed to estimate use values.
- The use of surveys allows to collect relevant socioeconomic and attitudinal data on the respondents that could be relevant for understanding the variables influencing social preferences and choices.
- The use of surveys allows to estimate hypothetical changes and their impact before they have taken place.
- Participative/deliberative approaches before valuing the good or service at stake seem to provide with more stable results.

Weaknesses:

- Preferences for non-use values tend to be less stable
- Complex questionnaire development and data analysis.
- Budget and time demands are high.
- High risk of biases that may lead to inaccurate WTP estimations.

Contingent Valuation

The contingent valuation method is a questionnaire-based technique that seeks to discover individual preferences for an environmental change. These are the only methods that can assess non-use values of ecosystems but can also be used to estimate use values generated by the ecosystems. In addition, due to their hypothetical nature, these methods can be used to assess social preferences ex-ante, i.e., for changes that have already not taken place. The basic premise of the contingent valuation method is that individuals are sensitive to a given environmental change and that their preferences could be measured in terms of their WTP to undergo (or their willingness to accept a compensation to avoid) this change. Therefore, the given change is presented to individuals through a survey where the environmental change is presented and where people are asked to state their WTP or their willingness to accept the given environmental change.

Strengths:

- They are the only available methods to estimate non-use values.
- They can also be employed to estimate use values.
- The use of surveys allows to collect relevant socioeconomic and attitudinal data on the respondents that could be relevant for understanding the variables influencing social preferences and choices.
- The use of surveys allows to estimate hypothetical changes and their impact before they have taken place.
- Participative/deliberative approaches before valuing the good or service at stake seem to provide more stable results.

Weaknesses:

- Preferences for non-use values tend to be less stable.
- Complex questionnaire development and data analysis.
- Budget and time demands are high.
- High risk of biases that may lead to inaccurate WTP estimations.

7.2.3 Other Valuation Options

Multi-Criteria Analysis

Multi-criteria analysis (MCA) is a decision support method that can be used to evaluate different alternatives. These alternatives may be very broad (e.g. different policy options) or concrete cases of applied policy instruments. Applying MCA helps to compare alternatives according to their performance with regard to a selected set of evaluation criteria. These performances are presented in a so called performance matrix, or consequence table. In this matrix each column represents an alternative (case) and each row describes the performance of the alternative against each criterion. In a basic form of MCA, this performance matrix may be the final product and each user can use this matrix to make their own judgement.

Strengths:

- Enables account to be taken of project impacts that are not easily given monetary values.
- Facilitates stakeholder involvement.
- Makes the appraisal and decision-making process more transparent.

Weaknesses:

- No built-in standard value, as it applies project specific values (criteria and weights).
- Comparisons between studies with different valuation criteria and weights are very limited.
- Requires well developed participation processes and strongly depends on stakeholder willingness to participate.

Benefit Transfer

Benefit transfer method is not a valuation method as such, but it is a method that involves transferring economic estimates from previous studies of similar changes in environmental quality to value the environmental change at a new policy site. It is defined as the transfer of existing estimates of non-market values to a new study which is different from the study for which the values were originally estimated (Boyle and Bergstrom, 1992). Thus, the basic goal of benefit transfer is to estimate benefits for one context by adapting an estimate of benefits from some other context. Benefit transfer is often used when it is too expensive and/or there is too little time available to conduct an original valuation study, yet some measure of benefits is needed. It is important to note that benefit transfers can only be as accurate as the initial study. In order to undertake a robust benefit transfer estimate, detailed information is needed about the study site, the previous environmental change valued, the population and the study methodology (Morrison, 2001). There are two main forms of the benefit transfer method:

1. Unit transfer method is the simplest method to transferring benefit estimates from a study site, or as a mean from several study sites, to a new policy site.
2. Function transfer method transfers a benefit function from another study. The benefit function statistically relates peoples' WTP to ecosystem characteristics and the people whose values were originally elicited.

Strengths:

- Benefit transfer is typically less costly than conducting an original valuation study.
- Economic benefits can be estimated more quickly than when undertaking an original valuation study.
- The method can be used as a screening technique to determine if a more detailed, original valuation study should be conducted.
- The method can easily and quickly be applied for making gross estimates of recreational values. The more similar the sites and the recreational experiences, the fewer biases will result.

Weaknesses:

- Benefit transfer may not be accurate, except for making gross estimates of recreational values, unless the sites share all of the site, location, and user specific characteristics.
- Relevant studies for the policy or issue in question may not be available.
- It may be difficult to track down appropriate studies, since many such studies are not published.

8. Recommendations: Phase II of Non-Market Impact Valuation for Fisheries RD&E

The purpose of the current study (Phase I) was to assess and understand the existing range of data/literature associated with the valuation of non-market impacts of fisheries and aquaculture RD&E. This assessment was required to (1) increase the resources available to analysts involved in assessing and estimating the impact of FRDC's RD&E investments, and (2) identify key information gaps in the literature where FRDC may fund future non-market valuation studies to improve the sectors ability to demonstrate the positive impacts of fisheries and aquaculture research. The following sections outline the recommendations for such future non-market valuation studies that would constitute Phase II of the FRDC's non-market impact valuation investment.

8.1 Priority Areas for Future Non-Market Studies

As described in Section 5.4 and Section 6, the main areas requiring further benefit estimation studies include:

- Value of fisher satisfaction,
- Contribution of fish habitat to carbon sequestration and storage,
- Willingness to pay for maintenance of biodiversity and/or ecosystem conservation,
- Willingness to pay for fish welfare, particularly farmed fish,
- Industry stakeholders' WTP for improvements to human health and wellbeing, and
- Social equity and maintained or enhanced social capital for fishers and fishing communities.

Though some international literature exists for a few of the above priority areas, there are limited Australian studies from which to draw relevant information and data. Further, though there is some literature on biodiversity and species protection values, such studies are typically species and/or site specific, therefore there is considerable space for FRDC to contribute to the body of literature for biodiversity and ecosystem maintenance issues specifically relevant to Australian fisheries and aquaculture.

8.2 Potential Methods for Future Studies

Table 3 provides a summary of suggested/ potential non-market valuation methods that could be applied to estimate values for the key areas identified in the gap analysis for FRDC RD&E.

Table 4: Potential Valuation Methods for Priority Areas for the Future Valuation of Impacts of FRDC RD&E Investments

Priority Area	**Potential Valuation Method(s)**
Value of fisher satisfaction	• Stated preference methods (choice modelling or contingent valuation) • Travel cost modelling
Carbon sequestration and storage (Blue carbon)	• Market based valuation • Avoided social cost of pollution
WTP for fish welfare	• Stated preference methods
WTP for improvements to human health and wellbeing	• Stated preference methods
Value of social equity	• Stated preference methods
Landscape and local amenity	• Hedonic property valuation • Stated preference methods
Value of social capital	• Stated preference methods

8.3 List of Australian Organisations and Personnel

Based on the literature review and gap analysis, a list of Australian organisations and personnel with experience and/or expertise in the area of non-market valuation was developed. This list below is indicative and should not be considered exhaustive.

Organisations

There are a wide range of Australian based organisations and independent consultants that may provide economic consultancy services including non-market valuation. For example, NCEconomics and Agtrans Research (current report authors) have experience with non-market economic valuation research and methods, incorporating non-market valuation studies into cost-benefit analyses and have access to networks of other economic/academic professionals with additional research expertise.

Some of the higher profile organisations with capacity/capability in the area of non-market economic valuation include:

- The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES)
- The Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- The University of Queensland
- Queensland University of Technology
- Central Queensland University
- The University of Tasmania
- The University of New England
- The Australian National University
- The University of Western Australia
- Institute for Marine and Antarctic Studies, Tasmania
- Charles Sturt University

Experienced Personnel

There are a significant number of experienced personnel across Australia that have experience and expertise in non-market valuation methods. A list of such people, based on the literature reviewed in this report, includes (alphabetical order):

- Amar Doshi, Economist, Queensland Competition Authority
- Atakelty Hailu, Associate Professor, University of Western Australia
- Clem Tisdell, Emeritus Professor, University of Queensland
- Clevo Wilson, Professor, Queensland University of Technology
- David Pannell, Professor, University of Western Australia
- Diane Jarvis, Senior Lecturer Economics, James Cook University
- Helen Scarborough, Associate Professor, Deakin University
- Jeff Bennett, Emeritus Professor, Australian National University
- Jill Windle, Central Queensland University
- John Rolfe, Professor, Central Queensland University
- Marina Farr, Economist, Department of Agriculture and Fisheries Queensland
- Mark Morrison, Professor, Charles Sturt University
- Michael Burton, Associate Professor, University of Western Australia
- Michelle Esparon, Adjunct Research Fellow, James Cook University
- Natalie Stoeckl, Associate Dean, University of Tasmania
- Prabha Prayaga, Central Queensland University
- Robert Curtotti, Manager of Fisheries Economics, ABARES
- Robert Gillespie, Principal, Gillespie Economics, Sydney

- Sarah Jennings, Doctor of Economics, University of Tasmania
- Satoshi Yamazaki, Senior Lecturer in Economics, University of Tasmania
- Sean Pascoe, Marine Resource Economist, CSIRO
- Silva Larson, Senior Environmental and Social Consultant, Aqua Energie LLC
- Steven Rust, Marine Resource Economist, Institute for Marine and Antarctic Studies

8.4 Ongoing, periodic update of the non-market study database

To ensure that the fisheries and aquaculture impact assessment data remain current and valid for future analyses of FRDC's RD&E performance, it is recommended that FRDC engage suitably qualified persons to periodically monitor and/or review the Australian and international non-market valuation literature associated with impacts of the FRDC's RD&E investments (described in Section 4) and update the non-market study database. This could be completed, for example, every five years in line with the preparation of the next five-year FRDC RD&E Plan.

9. Conclusions

The study produced a database of existing non-market valuation studies that may be useful resources for future impact assessments/evaluations of fisheries and aquaculture RD&E investments. Through the FRDC RD&E impact review, non-market literature review and gap analysis, the assessment found that the main areas requiring further impact estimation studies in Phase II of the process include:

- Value of fisher satisfaction,
- Contribution of fish habitat to carbon sequestration and storage,
- Willingness to pay for maintenance of biodiversity and/or ecosystem conservation,
- Willingness to pay for fish welfare, particularly farmed fish,
- Industry stakeholders' WTP for improvements to human health and wellbeing, and
- Social equity and maintained or enhanced social capital for fishers and fishing communities.

Further, though some international literature exists for a few of the above priority areas, there are limited Australian studies from which to draw relevant information and data. Also, though there is a deep literature on biodiversity and species protection values, such studies are typically species and/or site specific, therefore there is considerable space for FRDC to contribute to the body of literature for biodiversity issues specifically relevant to Australian fisheries and aquaculture.

It is recommended also that the FRDC periodically review available Australian and international non-market valuation literature and update the non-market study database. This will ensure that impact valuation data remain current and valid to demonstrate the benefits of fisheries and aquaculture RD&E.

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