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# An Impact Assessment of FRDC Investment in 2012-015: Improving confidence in the management of the Blue Swimmer Crab (*Portunus armatus*) in Shark Bay

**Agtrans Research**

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**An Impact Assessment of FRDC Investment in 2012-015: Improving confidence in the management of the blue swimmer crab (*Portunus armatus*) in Shark Bay**

**Project 2016-134**

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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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Mervi Kangas, Principal Research Scientist, Department of Primary Industries and Regional Development, Western Australia.
Nick Caputi, Department of Primary Industries and Regional Development, Western Australia.

# Abbreviations

| | |
|---|---|
| ABS | Australian Bureau of Statistics |
| BCR | Benefit-Cost Ratio |
| BSC | Blue-Swimmer Crab |
| CRRDC | Council of Rural Research and Development Corporations |
| DAWR | Department of Agriculture and Water Resources |
| DPIRD WA | Department of Primary Industries and Regional Development, Western Australia |
| FRDC | Fisheries Research and Development Corporation |
| MIRR | Modified Internal Rate of Return |
| OCS | Office of the Chief Scientist |
| PVB | Present Value of Benefits |
| RD&E | Research, Development and Extension |
| TACC | Total Allowable Commercial Catch |

# Executive Summary


**What the report is about**

This report presents the results of an impact assessment of a Fisheries Research and Development Corporation (FRDC) investment in *Improving confidence in the management of the Blue Swimmer Crab (Portunus armatus) in Shark Bay*. The project was funded by FRDC over the period July 2012 to March 2017.

**Methodology**

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

**Results/key findings**

The investment has likely contributed to. Several economic, social and environmental impacts/potential impacts were identified. The most significant impact was the increased revenue to Shark Bay Blue Swimmer Crab (BSC) fishers through an increased Total Allowable Commercial Catch (TACC) because of the environmental, and biological outputs from the project.

**Investment Criteria**

Total funding from all sources for the project was $2.20 million (present value terms) with FRDC investment in the project totalling $0.96 million. The investment produced estimated total expected benefits of $7.28 million (present value terms). This gave a net present value of $5.08 million, an estimated benefit-cost ratio (BCR) of 3.31 to 1, an internal rate of return of 15.9% and a modified internal rate of return (MIRR) of 9.4%.

**Conclusions**

While several economic, environmental, and social impacts identified were not valued, the impacts were considered indirect, uncertain and/or minor compared with the impact valued. Nevertheless, combined with conservative assumptions for the impact valued, investment criteria as provided by the valuation may be underestimates of the actual performance of the investment.



### Keywords

**Impact assessment, cost-benefit analysis, Blue swimmer crab, *Portunus armatus*, marine heat wave, recruitment, fecundity, growth, biomass dynamics model, Shark Bay, Western Australia, management.**

# Introduction

The Fisheries Research and Development Corporation (FRDC) required a series of impact assessments to be carried out annually on a number of investments in the FRDC Research, Development and Extension (RD&E) portfolio. The assessments were required to meet the following FRDC evaluation reporting requirements:

- Reporting against the FRDC 2015-2020 RD&E Plan and the Evaluation Framework associated with FRDC's Statutory Funding Agreement with the Commonwealth Government.
- Annual Reporting to FRDC stakeholders.
- Reporting to the Council of Rural Research and Development Corporations (CRRDC).

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

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

The 20 investments were selected through a stratified, random sampling process such that investments chosen spanned all five FRDC Programs (Environment, Industry, Communities, People and Adoption), represented approximately 26% of the total FRDC RD&E investment in the overall population (in nominal terms) and included a selection of small, medium and large FRDC investments.

Project 2012-015: *Improving confidence in the management of the Blue Swimmer Crab (Portunus armatus) in Shark Bay* was selected as one of the 20 investments and was analysed in this report.

# General Method

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

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

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

# Background and Rationale

## Background

The Shark Bay Blue Swimmer Crab Fishery is located in the Gascoyne region of Western Australia. It is unknown whether the stock of Blue Swimmer Crabs (BSC) within Shark Bay are self-recruiting and/or experience immigration from other BSC fisheries. The BSC in Shark Bay are managed as an independent fishery.

There are three main commercial harvest sectors that catch BSC in Shark Bay, the crab trap sector, the prawn trawl sector and the scallop trawl sector. The BSC fishery began as an exploratory fishery in the 1980s, moving to an experimental trap fishery in 1998 to assess further expansion. The Shark Bay BSC Fishery has grown substantially and became the highest value BSC fishery in Australia. Substantial increases in landings of BSC in Shark Bay between 2000 and 2010 caused stock sustainability concerns for the fishery management. Annual catches reached 800 tonnes around 2008, and from 2008 onwards, annual fishery surveys provided signs of a decrease in the mean abundance of mature females.

However, the extreme marine heatwave event that occurred in the summer of 2010/11 resulted in a recruitment failure and low adult survival in Shark Bay in late 2011. The marine heatwave resulted in the BSC fishery in Shark Bay having a voluntary closure imposed from April 2012 to November 2013 to allow stocks to recover. A proposed plan to cap commercial catch levels was discussed with the industry before the closure. Commercial fishing of BSC in Shark Bay was allowed to resume in late 2013.

## Rationale

Project 2012-015 was undertaken to better understand the biology of the BSC stock in Shark Bay and determine appropriate sustainable harvest levels. The aims of the project were later updated to include an investigation into the causes of the 2011 recruitment failure and to determine key biological and environmental parameters for BSC in Shark Bay to enable sustainable management and harvest of crabs once a level of recovery was observed in the fishery.

There was also a need to understand the economics of the fishery, as there were crab trap, prawn trawl, and scallop trawl sectors all sharing the BSC resource.

There was also an opportunity to hold a national workshop on BSC, as the previous workshop was held in 1998. A new workshop presented an opportunity to discuss different management strategies from across the different BSC fisheries of Australia and help understand how future climate trends may affect BSC fisheries across Australia.

# Project Details

## Summary

Project Code: 2012-015

Title: Improving confidence in the management of the Blue Swimmer Crab (*Portunus armatus*) in Shark Bay.

Research Organisation: Department of Primary Industries and Regional Development – Western Australia (DPIRD WA)

Principal Investigator: Mervi Kangas

Period of Funding: June 2012 to March 2017

FRDC Program Allocation: Industry (60%), Environment (40%)

## Objectives

The project's key objectives were:

1. To examine key drivers of the blue swimmer crab recruitment in Shark Bay, particularly environmental factors associated with low recruitment
2. Develop and implement a stock rebuilding strategy
3. Develop a harvest strategy for improved management of the stock
4. Determine the socio-economic significance of the blue swimmer crabs to the commercial trap and trawl sectors in Shark Bay
5. Host the Third National Workshop on Blue Swimmer Crab in 2015

## Logical Framework

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

Table 1: Logical Framework for Project 2012-015

| | |
|---|---|
| Activities and Outputs | • A review of the history of the BSC Shark Bay fishery was undertaken to detail the development of the fishery to 2016. The review outlined the historical data of BSC caught and development of a Total Allowable Commercial Catch (TACC) process.<br>• Historical catch data and current stock monitoring through fishery-independent surveys were used to study aspects of the fishery. The data included a trap monitoring program between 2000 to 2011, an annual November trawl survey beginning in 2002, and an expanded, fishery-independent, crab trawl survey beginning in 2012.<br>• A preliminary biomass dynamic model for BSC was developed. The model allows testing of management strategies and potential catch to see how stock recovery and how mature biomass changes in the following years. The model is based on the observed survey and expected catch rates.<br>• Surveys were carried out over four periods (February, April, June, November) over four consecutive years (16 surveys in total) to determine several key indicators such as peak spawning biomass, residual spawning biomass, and peak recruitment biomass. Also, the mean densities of crabs were recorded, and growth analyses were undertaken.<br>• The study area of the Shark Bay fishery was established using a swept area analysis. Two areas were included in the surveys; Area A (covering 657 square |

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|---|---|
| | nautical miles (nm)$^2$) and Area B (covering most of the crab trap and trawl area at 1,604 nm$^2$).<br>• The survey trawls were taken in areas where BSC were known to be located. The surveys covered 70% of the fishery, despite not being able to sample in shallow habitats, and took into account all areas of the fishery, not just the areas where fishers trawl, to ensure unbiased survey data. Captured crabs were separated into, male, female, and ovigerous female.<br>• Growth analysis involved a single stage process, with 1,000 crabs selected per survey. Seasonal Sea Surface Temperature affecting growth indicated that when temperatures began to decrease, growth rates for BSC increased, and when temperatures started to increase, growth rates began to decline.<br>• Research on the growth dynamics of BSC in Shark Bay was undertaken. Shark Bay BSCs were found to have a different growth pattern to BSCs in other regions of Western Australia with different climates. From the growth measurements, the maturity of female BSC was revised upwards from 92 mm carapace width (CW) to 110 mm CW.<br>• The estimated unfished biomass of BSC in Shark Bay was 1,319 tonnes, based on the biomass dynamics model used. The results of the surveys showed stock recovery since the April 2012 closure, and that stock levels had stabilised since fishing had resumed in November 2013.<br>• The cause of the heatwave that led to the 2011 BSC stock decline in Shark Bay was determined to be associated with a strong La Nina event, a strong Leeuwin Current, and a high heat flux from the atmosphere (around February 2011).<br>• The surveys re-affirmed that peak BSC spawning occurs in winter. BSC recruits from spawning are detected mainly in February, approximately nine months after spawning, and the growth from spawning to harvest was approximately 18 months.<br>• A risk assessment was undertaken by looking at different TACC and hypothetical catch levels. The research assessment in 2014 while the fishery was still recovering indicated that at catch levels between 300 – 371 tonnes p.a., it was possible that a major stock depletion would occur in the future.<br>• The project findings in 2014 indicated that the 2014/15 TACC level of 450 t p.a. was too high and constituted a high risk to stock sustainability as catches above 400 t had not been achieved since the heatwave event.<br>• Economic analysis of the BSC fishery was undertaken. Data were collected via interviews and a survey questionnaire. Face to face interviews were held in Carnarvon, Perth, and Fremantle with licence holders and processors. All licenced trap crabbers were interviewed, along with 17 out of 18 prawn trawl fishers. Scallop fishers did not take part. Two processers were also interviewed, covering 90% of the BSC processed.<br>• The economic performance of the BSC fishery was assessed using four criteria: Gross Value of Production, profitability, supply chain resilience, and employment and flow-on benefits.<br>• The project obtained beach price data from Australian Bureau of Agricultural and Resource Economics and Sciences for four seasons, 2010/11 to 2013/14. For 2013/14 the beach price was reported to be $5.24 per kg. The beach price varied from the average price of $7.00 per kg revealed by the interviews from vessels. The interview prices did not include freight and marketing costs.<br>• Baseline long-term profitability measures were developed for both the crab trap and prawn trawl sectors. The economic profit analysis considered the industry as a whole, not individual business profitability. The analysis showed there was no economic profit as, on average, capital cannot be replaced across the industry.<br>• Analysis of profitability at the time when the TACC was 400 t indicated that the average crab trap fisher receives approximately $85,000 of accounting profit per |

| | |
|---|---|
| | year but experienced an approximate economic loss of $180,000 per year. The project concluded that unless catches increase or prices increase, some businesses will not be viable long-term.<br>• Scenario analysis was undertaken to investigate different levels of profitability for different crab prices and catch rates for both crab trap and prawn trawl fisheries. Prices were varied between $4 to $11 per kg based on historical beach prices; the scenario assumed a business operating a single vessel.<br>• The analysis found that, at 2013/14 beach prices of $5.24 per kg, the total catch would need to be 123 t per vessel per year for crab trap fishers to have zero economic profit. If 2013/14 catch levels remained constant (reported as 89 t per vessel per year), there would need to be a beach price of $7.26 per kg for crab trap fishers to have zero economic profit. For the prawn trawl sector, at prices of $5.24 per kg, the analysis found that catches would need to increase to 19.7 tonnes per vessel per annum from 7.5 tonnes to have zero economic profit (holding prawn catch and price constant).<br>• Supply chain resilience also was explored to identify where benefits from the BSC fishery are captured, to identify vulnerabilities in the supply chain, and to understand business practices. Upstream beneficiaries were mainly fuel, ice, bait, and maintenance (only considered for the trap sector). Downstream beneficiaries were the processing facilities.<br>• It was estimated that the Shark Bay BSC fishery contributed $0.386 million to the Gascoyne region in direct labour spending (after the closure) with the prawn trawl sector (crab catch component) contributing $0.462 million to the Gascoyne region in direct labour spending.<br>• When the fishery reopened for the 2013/14 season, the trap sector only took 176 tonnes compared to its 267 tonnes allocation, with the prawn trawl sector taking 196 tonnes above its allocation of 135.2 tonnes; this was due to quota swapping.<br>• It was recommended that collection of price data be improved to gauge the profitability and sustainability of the industry properly.<br>• Analysis showed 13 out of 18 prawn trawl vessels are over 25 years old. The age of the vessels means that prices or volume will have to change quickly otherwise some vessel owners will not be able to replace capital.<br>• The analysis concluded that the prawn trawl sector might have a higher probability of long-term viability due to the prawn trawl sector having a fall-back species (prawns), compared to the crab trap sector.<br>• The report noted that crab businesses in the future will need to make decisions around transfer and leasing of quotas to remain viable in the future.<br>• The project team also organised the third national workshop on Blue Swimmer Crabs at the Western Australian Fisheries and Marine Research Laboratories, Hillarys, Perth, Western Australia on 3-4 June 2015.<br>• The workshop provided a platform for 60 researchers, fisheries managers, fishers and other stakeholders from across Australia to discuss and share BSC research and associated issues.<br>• Differences in management strategies were highlighted across different states.<br>• The project recommended that additional management measures need to be undertaken to ensure the sustainability of the fishery, although the project report did not specify the nature of the measures needed. |
| Outcomes | • As a result of the project and the biological model produced, the TACC for BSC for 2017/18 and 2018/19 has been recommended by the Shark Bay Crab Stock Assessment Working Group to increase to 550 tonnes after environmental conditions recovered. |

| | |
|---|---|
| | • Management of the BSC fishery is now accepting a Weight of Evidence approach to assessing the risk to stock suitability, for which the outputs of the project are included (Mervi Kangas, pers. comm., 2018).<br>• The project has directly informed the Shark Bay BSC Harvest Strategy to be published in 2018/19.<br>• Biological spawning and recruitment indices now are available, enabling future management on the recruitment rate of the BSC stock to be set at appropriate reference levels.<br>• From the increased knowledge transfer between different regions regarding BSC fishery policy, new and diverse ideas may cross over improving policy outcomes, but no follow up discussions have taken place to access any changes adopted (Mervi Kangas, pers. comm., 2018). |
| Impacts | • Increased revenue for Shark Bay BSC trap and prawn trawl fishers.<br>• Decreased probability of future stock collapse for the Shark Bay BSC fishery through improved management and regulations.<br>• Reduced likelihood of fisheries degradation.<br>• Improved social licence of BSC fishery.<br>• Maintained regional incomes and employment.<br>• Improved science and research capacity. |

# Project Investment

## Nominal Investment

Table 2 shows the annual investment (cash and in-kind) in project 2012-015 by FRDC and DPIRD WA.

Table 2: Annual Investment in the Project 2012-015 (nominal $)

| **Year ended 30 June** | **FRDC ($)** | **DPIRD -WA ($)** | **TOTAL ($)** |
|---|---|---|---|
| 2012 | 138,629 | 0 | 138,629 |
| 2013 | 66,159 | 335,295 | 401,454 |
| 2014 | 289,571 | 351,153 | 640,724 |
| 2015 | 129,470 | 289,464 | 418,934 |
| 2016 | 0 | 0 | 0 |
| 2017 | 51,453 | 0 | 51,453 |
| **Totals** | 675,282 | 975,912 | 1,651,194 |

## Program Management Costs

For the FRDC investment the cost of managing the FRDC funding was added to the FRDC contribution for the project via a management cost multiplier (1.122). This multiplier was estimated based on the share of 'employee benefits' and 'supplier' expenses' in total FRDC expenditure (5-year average) reported in the FRDC's Cash Flow Statement (FRDC, 2013-2017). This multiplier then was applied to the nominal investment by FRDC shown in Table 2.

For the DPIRD WA investment, it was assumed that program management and administration costs were already included in the nominal amounts shown in Table 2.

## Real Investment and Extension Costs

For the purposes of the investment analysis, the investment costs of all parties were expressed in 2017/18 dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2018). No additional costs of extension were included as the project included a high level of consultation with key stakeholders, including Government and others involved in setting TACC in the Shark Bay BSC fishery, and extension through published project findings.

# Impacts

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

Table 3: Triple Bottom Line Categories of Principal Impacts from Project 2012-015

| | |
|---|---|
| Economic | • Increased revenue for Shark Bay BSC trap and prawn trawl fishers through an increase in the TACC.<br>• Decreased probability of future stock collapse for the Shark Bay BSC fishery through improved management and regulations. |
| Environmental | • Reduced likelihood of fisheries degradation through improved scientific information available to fisheries management. |
| Social | • Improved social licence of BSC fishery due to improved management decisions.<br>• Maintained regional incomes and employment.<br>• Improved scientific and research capacity. |

**Public versus Private Impacts**

The impacts valued are both private and public impacts. The primary private impact is the increased TACC. There are also significant public impacts from the project. The public impacts include improved research on BSC that will lead to increased ecosystem sustainability into the future. There are also social spillovers from increased incomes and employment to the Gascoyne region as a result of the increased BSC catch.

**Distribution of Private Impacts**

The main private impacts from the project are to the crab trap fishers and prawn trawl operators within the BSC fishery in Shark Bay. They will capture the majority of private impacts. There also will be supply chain benefits, for example, through increased supply of crabs to be processed, and other auxiliary input and supply chain industries involved with the crab trap and prawn trawl sector.

**Impacts on other Australian industries**

There are not expected to be any major impacts to other Australian industries. There may be some minor impacts to other BSC fisheries around Australia due to the improved scientific and research capacity.

**Impacts Overseas**

No significant impacts to overseas parties are expected.

**Match with National Priorities**

The Australian Government's Science and Research Priorities and Rural RD&E priorities are reproduced in Table 4. The project findings and related impacts will contribute primarily to Rural RD&E Priorities 1 and 3, and to Science and Research Priority 2.

Table 4: Australian Government Research Priorities

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

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

# Valuation of Impacts

## Impacts Valued

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

The principal impact valued is the increased revenue to BSC fishers in Shark Bay. The increased in TACC, will increase revenue for fishers in Shark Bay through the increased BSC catch.

## Impacts Not Valued

Not all impacts identified in Table 3 could be valued in the assessment.

The economic impacts not valued included:

- Decreased probability of future stock collapse for the Shark Bay BSC fishery through improved management and regulations.

The above economic impact was not valued due to the uncertainty around the counterfactual. Without the project, the TACC would have been set conservatively, as assumed in impact one. Further into the future, it is unknown what information would have been available or used in determining TACC decisions. Assigning a probability on the scenario where the TACC would be set higher than sustainable is difficult and uncertain.

The environmental and social impacts not valued are:

- Reduced likelihood of fisheries degradation.
- Improved social licence of BSC fishery.
- Maintained regional incomes and employment.

The environmental and social impacts, while significant, could not be valued due to the difficulty of assigning a reasonable monetary value to non-market impacts, a lack of useable data for benefit transfer, and time and resource constraints.

## Valuation of Impact 1: Increased revenue to BSC fishers in Shark Bay

The project has increased knowledge of setting an appropriate TACC through improved knowledge of crab growth, population dynamics, and by developing a biomass-dynamic model for BSC. The biomass-dynamic model has increased confidence to increase the TACC while still allowing the fishery to be ecologically sustainable.

From the 2016/17 season, there were reports of higher than expected catches, with quotas being filled a month early, and with the BSC harvested being of a larger size (Stanley, 2017). The Shark Bay Working Group, because of the outputs of the project, have recommended a higher TACC of 550 tonnes for the 2017/18 and 2018/19 fishing seasons. The Minister for Fisheries Western Australia makes the final decision on the capacity of the fishery. The higher TACC is assumed to have been accepted by the Minister, with a probability of a 90% outcome. The alternative is assumed to be 450 tonnes, with a 10% outcome probability. The expected TACC is therefore 540 tonnes.

Because of the model and growth parameters produced by the project, there will be less conservative decisions made on the TACC of the BSC fishery, as there is an appropriate level of catch that can be set, without having an unacceptable risk of a stock collapse.

Therefore, the TACC will be higher than if the project did not take place as the model and improved BSC growth parameters still provide an ecologically sustainable TACC.

Historically BSC prices have fluctuated depending on the BSC demand and season. For this analysis a simplified assumption is made. The price for BSC is assumed to be a constant $5.41 per kg (Gaughan and Santoro, 2018).

There are three fishing sectors that catch BSC in Shark Bay; the crab trap sector, the prawn trawl sector, and the scallop trawl sector. All three have different catch allocations and cost structures, so the increased TACC needs to be treated separately between sectors. Information is only available for the crab trap and prawn trawl sectors. The scallop trawl sector did not provide economic information to the project. Therefore, no assumptions can be made on the scallop trawl sector. The 0.2% allocated to the scallop trawl sector therefore is not analysed. The annual costs for the crab trap and prawn trawl sector include depreciation on capital equipment and debt and interest costs.

There are 17 prawn trawl vessels and three crab trap vessels operating in the Shark Bay BSC fishery as of 2014 (Daley & van Putten, 2017). The number of prawn trawl and crab trap vessels are assumed constant into the future. The annual costs for the BSC crab trap fishery per year are $677,486 per vessel. The prawn trawl costs include costs of prawn trawling as the costs of catching crabs cannot be isolated. The annual cost for the prawn trawl sector is $1,522,169 per vessel, with prawn revenue of $1,300,000 per year per vessel. Prawn revenue is assumed constant. The costs for the crab trap sector and prawn trawl sector are assumed constant even with varying levels of catch, as the project assumed constant costs with varying catch levels in the profitability analysis for BSC fishers. All costs are assumed constant into the future.

The TACC was set at 450 tonnes for the 2014/15 and 2015/16 BSC fishing seasons. For the 2017/18 and 2018/19 BSC fishing season the expected TACC has been assumed to be set at 540 tonnes for the BSC fishery. The new TACC is assumed to remain constant into the future, as it is impossible to reasonably predict the environmental and biological factors that will affect the TACC in the years ahead. The TACC may increase into the future as the previous commercial catch before the closure was approximately 750 tonnes. As the allocation between the crab trap and prawn trawl sector is not known until the harvest strategy is approved, the split between the crab trap and prawn trawl is assumed to be the same as in 2013/14.

The allocation in 2013/14 was 264 tonnes for crab trap and 135.2 for prawn trawl. Hence the current valuation assumes 66% of the catch is crab trap and 33.8% prawn trawl. The assumed catch per vessel for crab trap is 89 tonnes each for three vessels, and for the prawn trawl sector, 7.5 tonnes each for 17 vessels.

With 66% of 540 tonnes, the trap sector can catch 121 tonnes of BSC per vessel per year for three vessels. The prawn trawl sector is allowed to catch a total of 11 tonnes of BSC per vessel per year for 17 vessels. The entire allocation of TACC is assumed to be caught each year.

While the profits of these vessels will still be negative if capital replacement costs are included, the fishery is still recovering. Therefore, it is possible that over time there may be a higher TACC that would change the negative economic profit into positive economic profit. Prices within the Shark Bay BSC fishery are also dependent on the BSC beach price. The BSC beach price has historically fluctuated between $4.25 per kg and $9.23 per kg. The increase TACC may help operators in Shark Bay cover their variable costs for longer, and enable them to replace their capital over time, when environmental, biological, and market conditions improve.

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

## Counterfactual

Without the project, there would be less confidence in raising the TACC levels to 540 tonnes, with a more conservative approach most likely adopted. Without the project for the years 2018 to 2022, the TACC is assumed to be set at 450 tonnes. After 2022 the TACC is assumed to be set at 85% of the TACC with the project, as stocks would have recovered, but the stock and science information that was provided by the project would not be available, and therefore a more conservative approach would have been taken. For the counterfactual, the price of BSC, cost of operations, number of vessels, and TACC split between crab trap and prawn trawl are assumed to be the same as the 'with project' scenario.

## Summary of Assumptions

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

Table 5: Summary of Assumptions

| Variable | Assumption | Source |
|---|---|---|
| **General** | | |
| Price of BSC per kg | $5.41 per kg | Gaughan, D. and Santoro, K., 2018 |
| Price of BSC per tonne | $5,410 per tonne | $5.41 * 1000 |
| Percentage of BSC TACC for crab trap fishing method | 66% | 264 tonnes/400 tonnes |
| Percentage of BSC TACC for prawn trawl fishing method | 33.8% | 135.2 tonnes/400 tonnes |
| **With Project 2012-015** | | |
| TACC Shark Bay BSC Fishery | 550 tonnes | Agtrans Research based on feedback from Mervi Kangas |
| Probability of 550 t TACC occurring | 90% | Agtrans Research |
| Alternative TACC Shark Bay BSC Fishery | 450 tonnes | Agtrans Research |
| Probability of 450 t TACC occurring | 10% | Agtrans Research |
| Expected TACC Shark Bay BSC Fishery | 540 tonnes | Agtrans Research |
| BSC TACC for crab trap | 356.4 tonnes per year | 66% * 540 tonnes |
| BSC TACC for prawn trawl | 182.5 tonnes per year | 33.8% * 540 tonnes |
| Number of vessels in crab trap sector (2013/14) | 3 | Daley & van Putten, 2017 |
| Number of vessels in prawn trawl sector (2013/14) | 17 | Daley & van Putten, 2017 |
| Annual BSC catch per vessel (crab trap) | 118.8 tonnes per year per vessel | 356.4 tonnes/3 vessels |
| Annual BSC catch per vessel (prawn trawl) | 10.74 tonnes per year per vessel | 182.5 tonnes/17 vessels |
| Annual BSC revenue crab trap per vessel | $642,708 per year per vessel | $5,410 * 118.8 tonnes |
| Annual BSC revenue prawn trawl per vessel | $58,103 per year per vessel | $5,410 * 10.74 tonnes |
| Annual prawn revenue per prawn trawl vessel | $1,300,000 per year per vessel | Daley & van Putten, 2017 |
| Annual costs for crab trap vessel | $677,486 per year per vessel | Daley & van Putten, 2017 |
| Annual cost for prawn trawl vessel | $1,522,169 per year per vessel | Daley & van Putten, 2017 |
| **Counterfactual** | | |
| TACC Shark Bay BSC Fishery (2018-2022) | 450 tonnes per year | Agtrans Research |
| BSC TACC for crab trap | 297 tonnes per year | 66% * 450 tonnes |
| BSC TACC for prawn trawl | 152.1 tonnes per year | 33.8% * 450 tonnes |
| BSC catch per vessel (crab trap) | 99 tonnes per vessel per year | 297 tonnes/ 3 vessels |
| BSC catch per vessel (prawn trawl) | 8.95 tonnes per vessel per year | 152.1 tonnes/ 17 vessels |
| Annual BSC revenue crab trap per vessel | $509,850 per year per vessel | $5150 * 99 tonnes |

| | | |
|---|---|---|
| Annual BSC revenue prawn trawl per vessel | $46,093 per year per vessel | $5150 * 8.95 tonnes |
| BSC TACC Shark Bay BSC Fishery after 2022 | 85% of TACC with the project | Agtrans Research |
| BSC TACC Shark Bay BSC Fishery after 2022 | 459 tonnes per year | 540 tonnes * 85% |
| Annual cost for crab trap operations | $677,486 per year per vessel | Daley & van Putten, 2017 |
| Annual cost for prawn trawl operations | $1,522,169 per year per vessel | Daley & van Putten, 2017 |
| **FRDC Program Allocation** | | |
| Program - Industry | 60% | FRDC |
| Program - Environment | 40% | FRDC |

# Results

All past and future costs and benefits were expressed in 2017/18 dollar terms using the Implicit Price Deflator for Gross Domestic Product. All costs and benefits were discounted to 2017/18 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the project investment period plus 30 years from the last year of investment (2016/17) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2014).

## Investment Criteria

Tables 6 and 7 show the investment criteria estimated for different periods of benefits for the total investment and the FRDC investment respectively. The present value of benefits (PVB) attributable to FRDC investment only, shown in Table 7, has been estimated by multiplying the total PVB by the FRDC proportion of real investment (43.62%).

Table 6: Investment Criteria for Total Investment in the Project Group

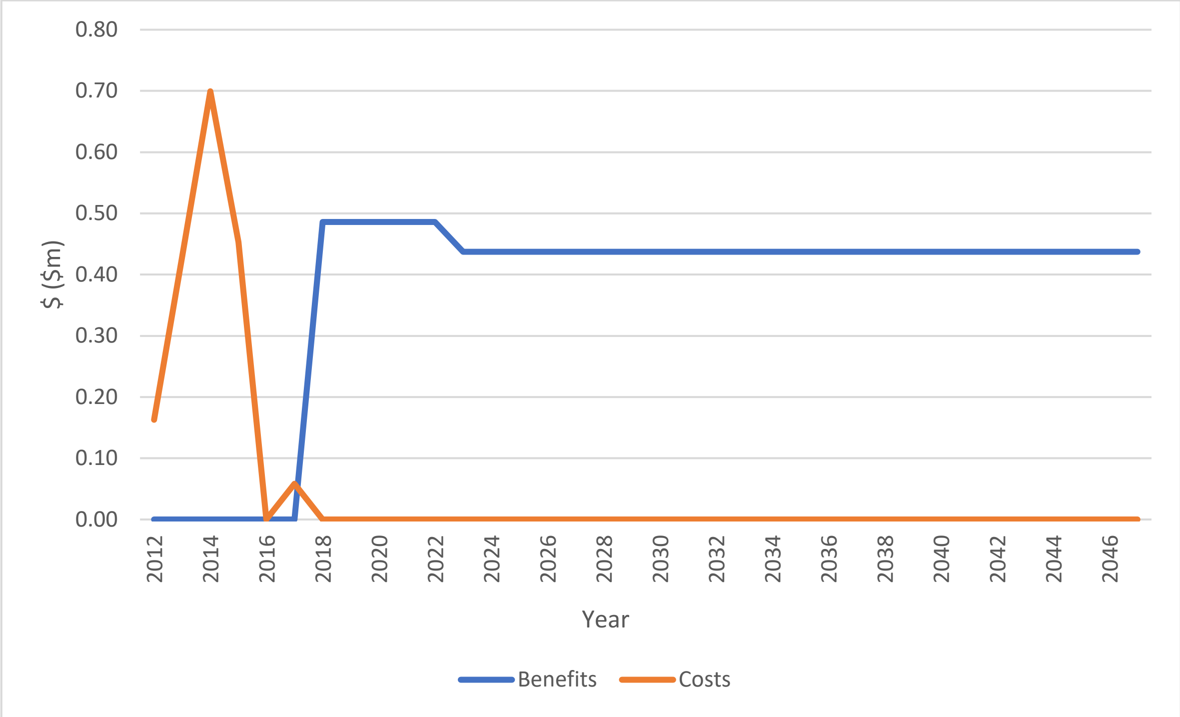
| **Investment Criteria** | **Years after Last Year of Investment** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0** | **5** | **10** | **15** | **20** | **25** | **30** |
| Present Value of Benefits ($m) | 0.00 | 2.21 | 3.77 | 4.99 | 5.94 | 6.69 | 7.28 |
| Present Value of Costs ($m) | 2.20 | 2.20 | 2.20 | 2.20 | 2.20 | 2.20 | 2.20 |
| Net Present Value ($m) | -2.20 | 0.01 | 1.56 | 2.78 | 3.74 | 4.49 | 5.08 |
| Benefit-Cost Ratio | 0.00 | 1.00 | 1.71 | 2.26 | 2.70 | 3.04 | 3.31 |
| Internal Rate of Return (%) | negative | 5.1 | 12.4 | 14.6 | 15.4 | 15.8 | 15.9 |
| MIRR (%) | negative | 5.1 | 11.5 | 11.3 | 10.6 | 10.0 | 9.4 |

Table 7: Investment Criteria for FRDC Investment in the Project Group

| **Investment Criteria** | **Years after Last Year of Investment** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0** | **5** | **10** | **15** | **20** | **25** | **30** |
| Present Value of Benefits ($m) | 0.00 | 0.96 | 1.64 | 2.18 | 2.59 | 2.92 | 3.18 |
| Present Value of Costs ($m) | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| Net Present Value ($m) | -0.96 | 0.00 | 0.68 | 1.21 | 1.63 | 1.96 | 2.21 |
| Benefit-Cost Ratio | 0.00 | 1.00 | 1.71 | 2.26 | 2.69 | 3.03 | 3.30 |
| Internal Rate of Return (%) | negative | 5.0 | 12.3 | 14.5 | 15.3 | 15.7 | 15.8 |
| MIRR (%) | negative | 5.0 | 11.4 | 11.3 | 10.6 | 10.0 | 9.4 |

The annual undiscounted benefit and cost cash flows for the total investment for the duration of the valued impacts from the FRDC project 2012-015 investment plus 30 years from the last year of investment are shown in Figure 1.

Figure 1: Annual Cash Flow of Undiscounted Total Benefits and Total Investment Costs




## Sensitivity Analyses

A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table 8 presents the results. The results showed a moderate sensitivity to the discount rate.

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

| **Investment Criteria** | **Discount rate** | | |
|---|---|---|---|
| | **0%** | **5% (base)** | **10%** |
| Present value of benefits ($m) | 13.36 | 7.28 | 4.74 |
| Present value of costs ($m) | 1.80 | 2.20 | 2.67 |
| Net present value ($m) | 11.56 | 5.08 | 2.07 |
| Benefit-cost ratio | 7.41 | 3.31 | 1.77 |

A sensitivity analysis was then undertaken for the assumption of the expected TACC due to the information provided by the project. This is the main variable the project has influenced and is a key driver of the main impact valued. The TACC increased by 10% in the optimistic scenario and decreased by 10% in the pessimistic scenario (therefore adjusting the expected TACC). Results of this sensitivity analysis are reported in Table 9.

Table 9: Sensitivity to the Expected TACC
(Total investment, 30 years)

| **Investment Criteria** | **Expected TACC** | | |
|---|---|---|---|
| | **Optimistic (589.5 tonnes)** | **540 tonnes (base)** | **Pessimistic (490.5 tonnes)** |
| Present value of benefits ($m) | 8.96 | 7.28 | 5.60 |
| Present value of costs ($m) | 2.20 | 2.20 | 2.20 |
| Net present value ($m) | 6.76 | 5.08 | 3.40 |
| Benefit-cost ratio | 4.07 | 3.31 | 2.54 |

The results from Table 9 indicate that the investment criteria are sensitive to the TACC, therefore the expected TACC. The results indicate the project is robust, with the pessimistic scenario still having a benefit-cost ratio (BCR) of 2.96. At a higher expected TACC of 585 tonnes, the crab trap industry was estimated to capture a small economic profit of $24,137 per vessel.

## Confidence Ratings and other Findings

The results produced are highly dependent on the assumptions made, some of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 10). The rating categories used are High, Medium and Low, where:

- High: denotes a good coverage of benefits or reasonable confidence in the assumptions made
- Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made
- Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 10: Confidence in Analysis of Project

| **Coverage of Benefits** | **Confidence in Assumptions** |
|---|---|
| Medium-High | Medium |

The coverage of benefits was assessed as medium-high as the primary impact of increased revenues to Shark Bay BSC fishers was valued but other impacts identified were not valued.

Confidence in the assumptions, used for valuation of the impact, was assessed as medium as many of the assumptions regarding the future were uncertain. The TACC to be set into the future is inherently unknown as it is heavily dependent on environmental and biological factors. While there is some evidence to suggest the project had an effect on the recent TACC setting, it is unknown what the size of the effect will be into the future. Assumptions made therefore were conservative in nature.

# Conclusions

The investment in the BSC project has likely resulted in a higher TACC that is sustainably set for BSC fishers in Shark Bay, leading to increased revenues. The investment also likely has contributed to improved environmental sustainability with a lower risk that the TACC may be set higher than sustainably acceptable.

Funding for the project totalled $2.20 million (present value terms) and produced estimated total expected benefits of $7.28 million (present value terms). This gave a net present value of $5.08 million, an estimated BCR of 3.31 to 1, an internal rate of return of 15.9% and a MIRR of 9.4%.

While several economic, environmental, and social impacts identified were not valued, the impacts were considered indirect, uncertain and/or minor compared with the impact valued. Nevertheless, combined with conservative assumptions for the impact valued, investment criteria as provided by the valuation may be underestimates of the actual performance of the investment.

# Glossary of Economic Terms

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

# References


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

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

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

Daley, R & van Putten, I. 2017, *Improving confidence in the management of the blue swimmer crab (Portunus armatus) in Shark Bay PART II: Socio-economic significance of commercial Blue Swimmer crabs in Shark Bay 2012-015*, FRDC.

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

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

Gaughan, D. and Santoro, K. (eds). 2018. Status Reports of the Fisheries and Aquatic Resources of Western Australia 2016/17: The State of the Fisheries. Department of Primary Industries and Regional Development, Western Australia. Retrieved July 2018 from http://www.fish.wa.gov.au/Documents/sofar/status_reports_of_the_fisheries_and_aquatic_resources_2016-17.pdf

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

Stanley, M. (2017). *Shark Bay 'breathing again' with return of blue swimmer crab stocks*. Retrieved April 2018 from http://www.abc.net.au/news/rural/2017-06-01/shark-bay-carnarvon-blue-swimmer-crab-season-best-in-decade/8550776