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FINAL REPORT

A review of projects concerned with improved exploitation of underutilised species

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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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FOREWORD

Catching unwanted fish species is an unavoidable consequence of commercial fishing. Some of this fish is bought from fishers at very low prices and used for low value products but the bulk of it is discarded at sea.

Many improvements have been made to fishing gear to reduce fishing bycatch, however there are still large volumes of underutilised species caught. Apart from some niche products, little of this product that is landed reaches wholesale and retail food markets because there is lack of demand for it, further complicated by failures in the supply chain. Most of the landed product is diverted to pet food, bait, and rendering for fish meal and oil.

This study was commissioned by the Fisheries Research and Development Corporation to investigate the factors that influence supply and demand of underutilised species. This project also sought to make recommendations on how FRDC might support future research on this subject.

The study was conducted in two parts:

1. The first part involved a review of previous and current FRDC projects focusing on developing commercial opportunities for underutilised species. This component was undertaken to assist FRDC and researchers in the design and execution of projects aiming to improve exploitation of underutilized species.

2. The second part involved interviewing operators at all levels of the supply chain and Principal Investigators of past and current FRDC projects to better understand the potentially competing objectives of public policies aimed at minimizing fish discards and commercial drivers that limit the harvest of underutilized species.

Key Words: Underutilised species, supply chain, checklist, waste, design thinking, value adding, discards.

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PART ONE: A REVIEW OF PROJECTS CONCERNED WITH IMPROVED EXPLOITATION OF UNDERUTILIZED SPECIES

PART ONE: EXECUTIVE SUMMARY

This project was undertaken to assist FRDC and researchers in the design and execution of projects aiming to improve exploitation of underutilized species. The project was initiated in response to the potentially competing objectives of public policies aimed at minimizing fish discards and commercial drivers that limit the harvest of underutilized species.

The expected outcomes from the project were:

1. A collated summary of all underutilized species projects supported by FRDC, and an analysis of lessons learned from each project.
2. A list of success criteria to be used as guidance for future applicants in preparing their projects and by FRDC in evaluating them.

Projects for review were identified by FRDC staff with knowledge of the area and by searching the FRDC project database back to 1992. Final reports and related documents were reviewed for each project. In many cases the Principal Investigator of the project was interviewed by telephone.

Forty-two projects with a total value of $6.6million were reviewed. These included 30 completed projects and 12 current projects.

Only seven of the completed projects were successful in that they achieved a commercial outcome, or are likely to achieve one, defined as significant volumes of fish being regularly harvested and sold into a market consistently. Six of the seven commercially successful projects used a whole supply chain approach.

Thirteen projects were concerned with market and or product development. All these projects but one achieved their technical objectives, however there was little evidence of the results being taken up by the industry.

Twelve projects were primarily concerned with management of fisheries from a biological perspective. Three of these projects were ancillary to new fisheries, and two were concerned with fishing operations and profitability, while the remainder were initiated by regulatory agencies wishing to identify underutilized species that could be exploited commercially.

The seven commercially successful projects had an impact on a scale of hundreds of tonnes of fish, rather than thousands of tonnes. They reflected successful commercialisation of a niche opportunity but are unlikely to produce a transformative impact on underutilized species at a national scale.

However, it should be noted that underutilization may just be a stage in a decades-long continuum of development of any fishery. There are commercially viable fisheries in existence now that did not exist thirty years ago. West Australian Octopus and Patagonian Toothfish are examples. These fisheries developed when economic conditions were favourable for them to do so. Therefore, it is not suggested that FRDC should cease investing in projects involving underutilized species. Rather, the approach to these projects could be revised, keeping in mind that:

- Despite the fact that all but one of the reviewed projects achieved their technical objectives, only seven were commercially successful.

- The scale of the successful projects was not transformational at a national level.
- The opportunity cost of these investments for FRDC needs consideration.

When considering investment in underutilized species in future, the following key factors must be considered:

- Tens of thousands of tonnes of underutilized species are discarded annually in Australia. Any transformational solution to this situation will require very significant changes.
- The fundamental problem with underutilized species for the Australian fishing industry is lack of market demand by domestic consumers.
- This means it is not profitable for Australian commercial fishers to harvest underutilized species.
- Attempting to change the economic equation by building demand in the domestic market is costly and high risk.
- The high cost structure of Australian fishing relative to export markets in Asia precludes access to those markets where there is a demand for low value fish.
- In light of the above, the decision to attempt exploitation of an underutilized species in the domestic or export market is a business one, likely to be based on low profit margins, that must be made by a commercial operator using their own data and networks.

The following recommendations are provided to assist FRDC and researchers in designing and implementing projects on this subject in future.

1. Projects should be initiated and led by a commercial operator (not an industry association) that signs the Funding Agreement with FRDC and is accountable for the outcomes.
2. Projects should be preceded by a financial analysis conducted by the commercial operator.
3. FRDC funds should only be used for research to fill knowledge gaps identified by the financial analysis.
4. If the research to fill the gaps is conducted by a public sector agency it should be subcontracted by the commercial operator, rather than FRDC.
5. Projects should only be approved when more than eighty per cent of the 34 success criteria in the checklist developed as part of this study are met.
6. These recommendations should also be applied to studies of the biology and status of underutilized species by fishery regulators that aim to identify species for commercial exploitation.

Under current policies in Australia, development of underutilized species is primarily a commercial activity in which it is questionable whether FRDC has a role. A more important role for FRDC might be in the investigation of policy options that drive better utilization of underutilized species. Such policies have been implemented by the European Union and are the subject of considerable debate.

INTRODUCTION

The Fisheries Research and Development Corporation (FRDC) has supported numerous projects that have sought to investigate commercial opportunities for the use of currently underutilized wild-caught fish species.

Underutilised species include:

- Fish that are caught, but not used for human consumption. These fish are returned to the sea (discarded) or used for low value products – e.g. fertilizer, bait.
- Fish that are not caught even though quota exists and licenses to harvest have been issued.
- Fish that are neither caught nor included in current licensing arrangement, yet might be caught in sustainable quantities.

The potential of underutilised species as a means of increasing the productivity and profitability of some fishing sectors has been identified by industry bodies and government agencies. Jurisdictions continue to prioritize research that explores the viability of underutilised species as seafood and FRDC continues to receive applications of this nature.

While the prospect of using fish that are readily available is attractive, there are likely to be numerous reasons why the fish are not currently exploited commercially. These reasons may be related to fishing processes, regulation, fisher competitive behavior, market perceptions, quality and supply chain arrangements.

Before investing additional funds in projects of this nature, FRDC required an evaluation of past projects to determine the factors behind their success or failure.

This analysis was conducted in an attempt to provide the basis for a decision matrix that can be used by project applicants and FRDC staff to design future projects.

Objectives

The objective of this project was to review previously funded FRDC research and prepare criteria for use by FRDC in guiding the establishment of future RD&E projects that aim to create commercial seafood opportunities from currently underutilised wild-caught species.

The expected outputs from the projects are:

1. A collated summary of all underutilized species projects supported by FRDC, and an analysis of lessons learned from each project.
2. A list of success criteria to be used as guidance for future applicants in preparing their projects and by FRDC in evaluating them.

MATERIALS AND METHODS

Projects for review were identified by FRDC staff with knowledge of the area and by searching the FRDC project database back to 1990.

As per the initial Terms of Reference, projects were included in this study if they met one of the following criteria:

A. Fish that are caught, but not used for human consumption. These fish are returned to the sea (discarded) or used for low value products – e.g. fertilizer, bait.
B. Fish that are not caught even though quota exists and licenses to harvest have been issued.
C. Fish that are neither caught nor included in current licensing arrangement, yet might be caught in sustainable quantities.

Final reports and related documents were reviewed for each project. In many cases the Principal Investigator of the project was interviewed by telephone.

As each project was reviewed, it became apparent that there is considerable cross over between the criteria described above.

For example, the passage of time has an impact on whether a fishery is regarded as underutilized or new. Any fishery that is currently regarded as new, was likely to have been regarded as underutilized in the past, before it was developed. Projects relating to the Western Australian Octopus Fishery, and the Coorong Pipi Fishery are included in the list of projects reviewed. At the time the projects were conducted the fishery resources were underutilized, but they are now established, profitable, "new" fisheries.

Consequently, when discussing underutilized species in future, is should be assumed that reference is being made to *currently* underutilized species.

A similar point can be made about older, more established fisheries, including Orange Roughy (*Hoplostethus atlanticus*), and Patagonian Toothfish (*Dissostichus eleginoides*). FRDC has invested significant funds in the development of these species. If this study was conducted in the 1990's these species would be included in category C above.

Categories A and B blend often converge. This is best exemplified by low value mackerel and tuna species, for which quotas have been issued but the species may be avoided by fishers, or unintentionally caught then discarded or put to low value use, owing to the economics of the catching arrangement and the market.

For the purpose of conducting this study it was found that segregating projects according to their investigative approach was more useful. Some projects covered the whole supply chain from fishing through to a finished consumer product. Other projects were ancillary or dealt with only one part of the chain, such as creation of new product opportunities, markets, harvest strategies, regulation of the resource, or simply increasing awareness of key players.

The projects reviewed in this study involved one or more of the following three investigative approaches:

- *Market and Product Development* – This approach generally aimed to break down barriers to market entry and improve economic returns through the development of new consumer products, improved marketing or education, and waste utilization.

- *Fishery Management* – Collection of data about the biology of the targeted species to determine its availability and sustainability and to develop decision support tools to assist in fishery management, development of harvest strategies improved operational efficiency.
- *Whole Supply Chain* – These projects involved a team of people responsible for fishing, processing, logistics and marketing.

Table 1 shows all the projects grouped according to these three approach categories

The results from two completed FRDC projects were particularly helpful in the interpretation of the projects reviewed in this study. These were:

- 2013-711.30: *New Opportunities for Underutilised Species* (J Howieson) This project developed an Excel database of currently underutilized species, describing the species, fishery, catch method, total allowable catch, actual catch and pricing.
- 2015-204: *Realizing economic returns of reducing waste through utilisation of discards in the GAB Trawl Sector of the SESSF.* (I Knuckey). This project report contains detailed information about the volume and value of currently underutilized species, along with extensive commercial insights.

The author is indebted to the principal investigators of these projects for many insights.

Table 1. List of all Projects Included in the Study, Grouped by Investigative Approach

Project no.	Project title	Invest'n Approach	Budget	Provider
2012-237	Tactical Research Fund: Decision tree and rapid assessment methodology for new fisheries	Fishery Management	$75,000	Anthony Hart – DPIRD
2015-200	Guidelines on a tiered, risk-based approach to bycatch management	Fishery Management	$432,809	S Nicol -DAWR
2015-202	Maximising net economic returns from a multispecies fishery	Fishery Management	$229,305	Sean Pascoe – CSIRO
2016-056	What could Australia's total sustainable wild fisheries production be?	Fishery Management	$157,000	David Smith – CSIRO
2016-146	Understanding factors influencing undercaught TACs, declining catch rates and failure to recover for many quota species in the SESSF	Fishery Management	$159,000	Ian Knuckey – Fishwell Consulting
2016-214	Identification of factors which impact on the profitability of individual GABTS operators and the fishery as a whole	Fishery Management	$129,544	Ian Knuckey – Fishwell Consulting
2017-023	ESD risk assessment for under-utilised species to facilitate structural reform of the SA Marine Scalefish Fishery.	Fishery Management	$109,546	Tony Fowler – SARDI
1992-125.31	Feasibility Study for Establishment of a Victorian Commercial Jellyfish Fishery	Fishery Management	$15,000	Terry Walker - MAFRI
1997-122	Ecologically sustainable development of the fishery for Patagonian Toothfish around Macquarie Island:	Fishery Management	$771,327	Xi He - CSIRO
1999-138	Jellyfish fishery development and assessment	Fishery Management	$322,832	Noel Coleman - MAFRI
2010-200	Innovative development of the *Octopus tetricus* fishery in Western Australia	Fishery Management	$381,465	Anthony Hart – DFWA
2011-024	Periwinkle fishery of Tasmania: supporting management and a profitable industry	Fishery Management	$161,436	Jeremy Lyle - UTAS
1992-125.24	Maximising economic returns in the NT Spanish Mackerel fishery	Product and Market Development	$26,307	Steven Slattery - DAFF QLD
1992-143	Publication of a seafood catering manual	Product and Market Development	$120,448	Francene Brown - DAFF QLD

Project no.	Project title	Invest'n Approach	Budget	Provider
1994-123	Value adding to seafood by application of modern drying techniques	Product and Market Development	$86,251	Steven Slattery - DAFF QLD
1994-166	Informing and capitalising on seasonality of Australian caught seafood	Product and Market Development	$10,000	Francene Brown - DAFF QLD
1997-300	Identification of market requirements for future development of the Australian Seafood Catering Manual	Product and Market Development	$25,929	Francene Brown - DAFF QLD
1997-301	Informing and capitalising on the seasonality of Australian seafood (stage 2)	Product and Market Development	$86,551	Francene Brown - DAFF QLD
1997-342	Hooking into Asian seafood markets: commercial development of selected under-utilised Australian fisheries resources for Asian markets	Product and Market Development	$278,810	Kevin Smith - DAFF QLD
1997-410	Development of value-adding products and preliminary marketing trials for Jack Mackerel (*Trachurus declivis*)	Product and Market Development	$39,324	Felicia Kow - AMC
2002-250	SEF Industry Development Subprogram: agricultural trials of a fish-based fertiliser (BioPhos) produced from Australian seafood processing wastes	Product and Market Development	$543,784	Aravind Surapaneni - MAFRI
2006-209	Developing targeted strategies for improving product quality through selected low value seafood supply chains	Product and Market Development	$325,270	Tom Riley - UWA
2007-245	Defining processing and packaging conditions for fresh and frozen soft shell crabs	Product and Market Development	$30,538	Steven Slattery - DAFF QLD
2008-321	Assessing the technology transfer and people skills requirements for the introduction of mullet processing on the east coast similar to Shark Bay frozen sea mullet fillets	Product and Market Development	$13,104	John Harrison - WAFIC
2008-717	Seafood CRC: improving quality of Australian Sardines through utilization of flow-ice technology	Product and Market Development	$20,411	Richard Musgrove - SARDI
2010-774	Seafood CRC: Successful Sardines - post-harvest optimisation and new product development for human consumption	Product and Market Development	$81,907	Kayron McNaughton – SARDI
2012-207	Adding value to seafood processing waste through the recovery of bioactive molecules	Product and Market Development	$497,338	Simone Osborne - CSIRO

Project no.	Project title	Invest'n Approach	Budget	Provider
2015-204	Realising economic returns of reducing waste through utilisation of bycatch in the GAB Trawl Sector of the SESSF	Product and Market Development	$125,000	Ian Knuckey – Fishwell Consulting
2015-505	Identifying opportunities for developing community supported fisheries in South Australia's small scale, multi-species, multi-gear community based fisheries	Product and Market Development	$20,000	Jonathon McPhail – PIRSA
2016-173	Trade Mission: Creating a niche Chinese market for NSW mixed finfish through the GFresh E-commerce platform	Product and Market Development	$12,753	Tricia Beatty - PFA
2016-207	Development of post-harvest handling technologies for the underutilised cross-jurisdictional Royal Red Prawn fishery	Product and Market Development	$187,253	Sue Poole – QLD DAFF
2016-208	Waste to profit in urchin fisheries: developing business opportunities to ensure fishery sustainability and safeguard reef dependent fisheries from destructive urchin grazing	Product and Market Development	$54,102	John Keane - UTAS
2017-050	Waste to profit in urchin fisheries: developing business opportunities to ensure fishery sustainability and safeguard reef dependent fisheries from destructive urchin grazing	Product and Market Development	$45,610	Simone Osborne - CSIRO
2007-209	SESSF Industry Development Subprogram: Adding value to a underutilised fish species (Silver Warehou)	Whole Supply Chain	$53,800	Malcolm McLaughlin –
2007-703	Seafood CRC: Intervention strategies to maintain the quality of value added products made from underutilised SESSF	Whole Supply Chain	$217,770	Sydney Fish Market
2010-706	Seafood CRC: accelerated new product development: blue swimmer crab pilot	Whole Supply Chain	$145,834	Janet Howieson – Curtin University
2012-230	Developing postharvest capability at the Lakes Entrance Fishermans Coop	Whole Supply Chain	$83,500	Matt Scott - Lakes Entrance Coop
2013-237	Identification and development of the domestic and export market requirements for packaged Pipis.	Whole Supply Chain	$87,500	Tom Robinson – GPHA
2013-711.30	Seafood CRC: New opportunities for underutilised species	Whole Supply Chain	$68,000	Janet Howieson – Curtin University
2013-711.40	Seafood CRC: New opportunities for seafood processing waste	Whole Supply Chain	$101,000	Janet Howieson – Curtin University

Project no.	Project title	Invest'n Approach	Budget	Provider
2015-225	Developing and testing a multi-species, automated fish in-feed system for a production line to add-value and supply large local markets, replacing imports	Whole Supply Chain	$150,000	Geoff Ellis - Lakes Entrance Coop
2016-224	Boosting fisher returns through smart value adding and greater use of underutilised species	Whole Supply Chain	$95,000	Ewan Colquhoun – Ridge Partners
	TOTAL		**$6,577,357**	

RESULTS

Forty-two projects with a total value of $6.6million were reviewed. These included 30 completed projects and 12 current projects.

Completed Projects

All the completed projects but one achieved their technical objectives.

Only seven of the completed projects were successful in that they achieved a commercial outcome, or are likely to achieve one. In this context, a successful commercial outcome is defined as significant volumes of fish being regularly harvested and sold into a market on a consistent basis. No financial analysis was conducted to determine the profitability of these enterprises. It was assumed that business was profitable if the industry participants continued the activity after the project was completed.

Six of the seven commercially successful projects used a whole supply chain approach. These projects involved people from all aspects of the prospective business, from fishing through to retailing.

Thirteen projects were concerned with market and or product development. All these projects but one achieved their technical objectives, however there was little evidence of the results being taken up by the industry.

Nine projects were ancillary to larger efforts to exploit underutilized species, but were not directly related to achieving a commercial outcome. The seven projects concerned with fishery management were in this group., including five projects that assessed biomass and sustainability of specific fisheries and two concerned with data collection and analysis. The other two ancillary projects involved publication of generic marketing and educational material.

The success rate of completed projects is summarized in Table 2.

Table 2. Success rate of completed projects according to type of project.

Project Approach	Total number of Completed Projects	Number of projects that achieved their objectives	No of projects that achieved a commercial outcome
Whole Supply Chain	10	10	6
Market and Product Development	13	12	1
Fishery Management	7	7	0
Total	**30**	**28**	**7**

Table 3 summarises the objectives, results and commercial outcomes of all the completed projects in the study.

Table 3. Summary of Completed, Relevant FRDC Projects
(CS = Commercially Successful? Y = Yes, N = No, A = Ancillary project)
(Categories: WSC = Whole Supply Chain, PMD = Product or Market Development, FM = Fishery Management)

Project	Cat.	Objectives	Summary of outputs	Commercial Outcomes	CS*
2007- 703 - Intervention strategies to maintain the safety and quality in a range of value added products made with underutilised SESSF species. PI: Sydney Fish Market	WSC	1. An assessment of the food safety risks 2. Identification and resolution of the critical quality issues. 3. Production of SFM branded value added products. 4. Capacity building within SFM and Southlands regarding the development of value added seafood product lines.	Seven packaged, value added products were produced from Gould's squid, Silver Warehou, Banana Prawns and other UUS. These were launched onto the domestic market branded as *Market Pride*. Can be argued that the SFM and other project participants did not have all the skills to produce these products cost effectively and to market them.	Ultimately cost of production could not be met by sales income and the concept was closed down.	N
2012-230 - Developing postharvest capability at the Lakes Entrance Fishermen's Co-operative. PI: Dale Sumner	WSC	Assessment of the commercial and culinary capabilities and marketing requirements of various seafood species including by-product	Feedback from consumers, retailers, distributors and media, identified that there are numerous species caught by LEFCOL which are "under-valued", due to poor understanding through the supply chain and at consumer level for their culinary and commercial capability.	Involved chefs, marketers, wholesalers and logistics.	Y
2013-711.30 New Opportunities for Underutilised Species. Saddletail Snapper	WSC	To investigate the use of injection with enzymes to soften Saddletail Snapper fillet to create a consistent product that can be marketed to the food service sector.	The injection process provided a consistent Saddletail Snapper product with improved textural properties. Large scale commercialisation	Likely to be commercially successful	Y

Project	Cat.	Objectives	Summary of outputs	Commercial Outcomes	CS*
PI: J Howieson			has been achieved and Australia Bay Seafoods is currently seeking suitable markets for the products.		
2013-711.30 Australian Salmon	WSC	1. Develop two new commercial opportunities for underutilized/low value species. 2. Develop and trial a framework for taking underutilised species to market 3. Develop an Australian underutilised species database	The project demonstrated that a range of fresh/frozen and value-added Australian Salmon products can be produced. These products have been demonstrated to have consumer/market appeal. A number of seafood suppliers have interest in commercialising such products. However the supply of fish is inconsistent which has prevented the market developing.	Problem with sporadic supply of fish. Small volume of products commercialized. Use of the resource has no increased.	N
2013-711.30 Finfish from the Pilbara Trawl	WSC	To develop new opportunities for underutilised and low value species caught in the Pilbara Finfish Trawl Sector	Six species identified for potential sale of fillets on the domestic market after off-shore processing, but off-shore processing arrangements failed. However, locally processed Blue Spot Emperor fillets are now commonly available across the retail and supermarket sector.	Fresh Blue Spot Emperor fillets are now an accepted product in Perth retail stores	Y
2013-711.30 High pressure pasteurisation trials for seafood product	WSC	To conduct trials using the commercial HPP machine in Manjimup on various packaged seafood products and assess the impact on	A range of existing species were found to be suitable for HPP. Cooked (but not raw) fin fish had extended	Meat extracted from processed Spiny crabs might be commercially successful	N

Project	Cat.	Objectives	Summary of outputs	Commercial Outcomes	CS*
		shelf-life, meat extraction, shucking and sensory quality	shelf-life after HPP, which may be useful for some UUS		
2013-711.40 - New Opportunities for Seafood Processing Waste PI: J Howieson	WSC	1. Develop at least three new value add opportunities from seafood processing waste. 2. Develop a framework for identifying and capitalising on opportunities for value adding of seafood processing waste	Included because some of the waste products can be argued to be UUS. E.g. pearl meat, scampi roe.	Shark Bay wild Scampi caviar is a new product now routinely available commercially	Y
2013-237- Identification and development of the domestic and export market requirements for packaged pipis. PI: GPHA	WSC	To develop new markets and products to increase the value of the total allowable annual catch allocated each year to commercial fishers.	MAP pipis, with a proven 10 day refrigerated shelf life were welcomed by more than half of all Australian businesses consulted. Detailed market entry strategy developed and implemented.	This is now an established, profitable fishery.	Y
2007- 209 - Adding value to an under-utilised fish species (Silver Warehou) PI: I Knuckey	WSC	1. Conduct research to confirm appropriate markets for Silver Warehou 2. Develop a new seafood product from Silver Warehou that will appeal to the consumer and is competitively priced to similar imported products 3. Adapt techniques to process Silver Warehou into suitable products 4. Establish training program for	Developed a method of bulk freezing, processing while partly thawed and packaging Silver Warehou that preserved the flesh's white appearance and was appealing to consumers. Direct involvement with major wholesaler / exporter (McLaughlins) Marketed to HK but stopped when HK company changed hands.	Unreliability of Asian market was too risky and supply of fish declined	N

Project	Cat.	Objectives	Summary of outputs	Commercial Outcomes	CS*
		processing staff to ensure product QA 5. Describe how the process applied to Silver Warehou can be adapted to other low value species			
2010-706 - Accelerated new product development: blue swimmer crab pilot	WSC	1. Develop at least two processed crab products ready for large scale production. 2. Pilot of an innovative new accelerated product development methodology	The project successfully developed new products and achieved substantial market sales.	This was more of a product development and diversification project, since the crab species involved is not underutilized.	Y
2015-204: Realising economic returns of reducing waste through utilisation of discards in the GAB Trawl Sector of the SESSF. PI: I Knuckey	PMD	To examine options to utilise fish that are currently discarded to both decrease wastage and increase profitability of the Great Australian Bight Trawl Sector (GABTS).	44% of the total weight of the catch is discarded. The main barriers to improved utilisation of discards in the GABTS are related to a lack of restaurateur, chef and consumer knowledge of the product and how to cook it. Considerable potential for increased utilisation of GABTS discards; particularly Latchets and Ocean Jacket Threshold price for the landed product needs to be adequately high to compensate fishing costs. Examined the potential of on board processing for fish silage.	Nil. Industry has not progressed the opportunities identified	N

Project	Cat.	Objectives	Summary of outputs	Commercial Outcomes	CS*
2008-321 - Assessing the technology transfer and people skills requirements for the introduction of mullet processing on the east coast similar to Shark Bay frozen sea mullet fillets PI: J Harrison	PMD	1. Investigate and assess the adoptiveness of the frozen mullet fillet product from Shark Bay for the Clarence River 2. 2. Identify ALL of the steps in the WA process and project these for the potential for a similar product for the Clarence.	This was a study tour that resulted in a report recommending development of a frozen and MAP packed mullet fillet product .	Study Tour results were not acted upon.	N
2008- 717 – Flow ice technology for sardines 2010-774 Successful Sardines: Post Harvest Optimisation and New Product Development for Human Consumption PI: K Naughton	PMD	1. To identify and implement optimised post-harvest value added processes (from raw material receipt to final product dispatch) 2. To develop, trial and evaluate a range of new products (from concept to test market) for human consumption	Species defined as UUS because attempting to move from aquaculture feed to human consumption. New products developed. But not taken to market because, fish available were too small, processors involved were enthusiastic but did not have sufficient experience, and no market strategy.	Nil. Insufficient skills and erratic fish supply.	N
2006-209 - Developing targeted strategies for improving product quality throug h selected low value seafood supply chains. PI: T Riley	PMD	1. To complete microbiological and temperature analyses of six seafood supply chains. 2. To determine the impact of spoilage organisms on product quality. 3. To identify and validate supply chain intervention and/or value-adding protocols which improve shelf-life or enable	Developed supply chain and processing interventions, including a QIM, to improve quality and marketability of Mussels and Australian Salmon.	No commercial uptake	N

Project	Cat.	Objectives	Summary of outputs	Commercial Outcomes	CS*
		the development of new products.			
1997-342 - Hooking into Asian seafood markets	PMD	To identify and select certain sustainable Australian under utilised fisheries resources and potential Asian markets suitable for their commercial development.	The final report contains a detailed summary of the research and efforts undertaken to market a selection of Australian under utilised and undervalued species products. Links were established with Supermarket to Asia, Austrade, and Queensland State Government Offices in Asia. A number of operators gained valuable experience of Asian markets.	No longer applicable.	A
1997-410 - Development of Value Added Products and Preliminary Marketing Trials for Jack Mackerel. PI: F Kow	PMD	Examine the potential of jack mackerel products for human consumption	At the time, the annual catch of Jack Mackerel was 9,000 t with less than 1% of the catch used for human consumption. Using the marketing name *Tasikana*, four products utilising the species were developed. Cold-smoked fillets, Hot and spicy satay fillets, Satay cold-smoked fillets and ocean jerky. The market potential of the products, targeting ethnic communities, was investigated in Sydney and Melbourne. A total of 1,105 people were surveyed and it was found that all the developed products	This appears to have been a very successful project. It is assumed that the profitability of these products in Australia was insufficient to warrant further investment by industry.	N

Project	Cat.	Objectives	Summary of outputs	Commercial Outcomes	CS*
			were liked by the great majority of the respondents.		
2007-245 Defining processing and packaging conditions for fresh and frozen soft shell crabs. PI: Steve Slattery	PMD	Identification of optimal process for packaging in MAP and most likely shelf life achievable.	This project was disrupted and ultimately terminated due to difficulties experienced by the industry participants. However, it contributed to building expertise on the handling of soft shell crabs	Project was not satisfactorily completed due to commercial difficulties	N
1992-125.24 Maximising economic returns in the NT Spanish Mackerel fishery PI: S Slattery	PMD	Investigate factors affecting quality of Spanish Mackerel during storage	Study found that fish handled correctly on ice could maintain quality for 14 days	No commercial uptake.	N
1991-087, 1997-300, 1992-143 Development and publication of a seafood catering manual. PI:F Brown	PMD	These projects aimed to provide a manual for restaurant and institutions to: Encourage better use and handling of seafood and to support greater use of low value species. Provide information on local alternatives to imported fish lines.	This manual was well received at the time.	Has now been superseded by the *Fish Files* website and materials.	A
1994-123 - Value adding to Seafood by Application of Modern Drying Techniques. PI: S Slattery	PMD	To produce appropriate samples of heat pump dried seafood for evaluation	Sixteen species were tested and valuable products produced. Evaluations by marketers were favourable. No progression to market evaluation was conducted	While drying fish is an effective way of storing and transporting them, this form of seafood is not popular in Australia and is produced at a lower cost overseas.	N

Project	Cat.	Objectives	Summary of outputs	Commercial Outcomes	CS*
1994-166 1997-301. Informing and capitalising on the seasonality of Australian seafood. PI: F Brown	PMD	1. To collect seasonality data for 97 Australian seafood species 2. To produce a seafood by seasons educational concept. 3. To Implement a marketing strategy for the seafood by seasons concept.	This project is linked to the catering manual project and is aimed at helping chefs use a wider variety of seafood.	Has now been superseded by the *Fish Files* website and materials.	A
2002-250 - Agricultural trials of a fish-based fertilizer (*BioPhos*) produced from Australian seafood processing wastes. PI: A. Surapaneni 2001-238 2004-254 SE Fishery Industry Development Program: facilitation, administration and promotion 2004, 2007	PMD	Comparison of the agronomic effectiveness of BioPhos with Superphosphate in a range of crops. These projects are listed because they provided the background to development of *Biophos* and the formation of the Australian Seafood Coproducts Company (ASCO)	Biophos was found to be equal to superphosphate as a fertilizer.	Biophos is now commercially available from the Australian Seafood Coproducts Company (ASCO)	Y
2012-207 - Adding value to seafood processing waste through the recovery of bioactive molecules. PI: S Warner	PMD	1. investigate abalone processing waste as a source of anti-inflammatory and anti-thrombotic molecules. 2. Screen Atlantic Salmon and Barramundi processing waste for bioactive molecules.	The investigation discovered a range of extracts that had bioactivity in *in-vitro* testing. The potential for these extracts to be used in nutraceutical and similar products was noted. There was no follow through with potential markets.	Although seafood companies were involved in supplying waste there was no involvement of end-users of the product.	N

Project	Cat.	Objectives	Summary of outputs	Commercial Outcomes	CS*
		3. Analyze the potential markets for the bioactive molecules.			
2011-024 - Periwinkle Fishery of Tasmania: Supporting Management and a Profitable Industry PI: J Keane	FM	To provide an assessment of the status of the periwinkle resource in Tasmania, to provide a basis for setting biologically meaningful minimum size limits, to evaluate market potential, and to produce a report card to aid in the sustainable development and management of the fishery.	The market for periwinkles has considerable potential for expansion. The Tasmanian periwinkle fishery is currently valued approximately $110,000, well below the potential value of $340,000 should the TAC be fully harvested. Notes the need for marketing.	No involvement of the supply chain	N
1997-122 Ecologically sustainable development of the fishery for Patagonian Toothfish around Macquarie Island. PI: Xi He	FM	Develop population models for the Patagonian Toothfish fishery and provide strategies for developing and managing the fishery.	Collection of significant amount of data on which to base management of the fishery.	Part of a major effort to develop this fishery	A
1992.125.31 - Feasibility Study for Establishment of a Victorian Commercial Jellyfish Fishery. PI: T Walker	FM	1. Provide order-of-magnitude estimates of jellyfish biomass in Port Phillip Bay. 2. Investigate harvesting and on-board storage techniques. 3. Trial jellyfish processing in Victoria, export procedures, and market acceptance in Asia	This project clearly established adequate biomass, fishing and processing techniques and market demand to warrant establishment of a fishery. The conclusion was: *In the short-term, it is envisaged a processing plant will be developed to process 1500 tonnes wet weight of C. mosaicus per year from Victorian bays*	No Commercial uptake	N

Project	Cat.	Objectives	Summary of outputs	Commercial Outcomes	CS*
			and inlets during 1998 and 1999 under a developmental fishery status. A full commercial fishery will be announced in 2000 and an appropriate TAC will be set and units of quota sold on the open market by Fisheries Victoria.		
1999-138 Jellyfish fishery development and assessment PI: N Coleman	FM	Estimate spatial and temporal variations in abundance of *Catostylus mosaicus* in Port Phillip Bay, Western Port and Corner Inlet during 2000, 2001 and 2002.	The project expanded the above project to other bays and investigated unexplained reduction in numbers of jellyfish. The data was not successfully applied commercially due to the low catch volume.	No commercial uptake	N
2010-200 - Innovative development of the Octopus fishery in Western Australia. PI: A Hart	FM	1. To describe the life history of *O. tetricus* in WA, including age, growth and reproduction. 2. Determine the fishing efficiency of octopus trigger traps. 3. Estimate potential harvest from octopus fisheries	Octopus has always been a byproduct of the rock lobster fishery, however targeted fishing for octopus was established in 2001. In 2010 the introduction of the trigger trap more than tripled the catch.	This study was a key source of information on which to base management and growth of the fishery.	A
1992-125.10 - Waste fish and fish waste - a study of NSW and Qld bycatch and by-product availability. PI: N Ruello	FM	To provide an assessment of the composition, volume and seasonal availability of bycatch in Australian fisheries.	This study was about standardizing data collection and analysis.	Nil	A
2012-237 - Decision tree and rapid assessment	FM	Shorten the time required to approve new fisheries.	The Rapid Assessment Model (RAM) was found to accurately and	Could be of value in faster assessment of UUS fisheries.	A

Project	Cat.	Objectives	Summary of outputs	Commercial Outcomes	CS*
methodology for new fisheries PI: A Hart			swiftly score development opportunities for new fisheries against respective scorecards for economics, sustainability, and social license.		

Checklist for Evaluation of Projects

FRDC project 2015-204 conducted a review of the literature relating to use of underutilized species in Australia and other countries and identified many supply and demand barriers to the use of bycatch and discarded species.

For the purposes of this study, the factors identified in the above study were modified and used to create a checklist to assess each completed project. The checklist contains 34 success criteria arranged into seven groups (Table 4).

Each project was analyzed to determine whether the number of success criteria met was correlated with commercial success. To simplify the scoring, the criteria were worded as questions such that a positive answer was “yes”. Answers to questions that were not applicable were left blank. The final score for each project was the percentage of all applicable questions to which the answer was yes. Individual projects that focused on the same species were combined for analysis.

Twenty-four completed, non-ancillary projects were assessed against the checklist. The results are summarized in Figure 1. Scoring of all projects against each criterion is shown in the Supplementary Materials.

The seven successful projects all scored better than 80 per cent, while all but two unsuccessful projects were below 50 per cent.

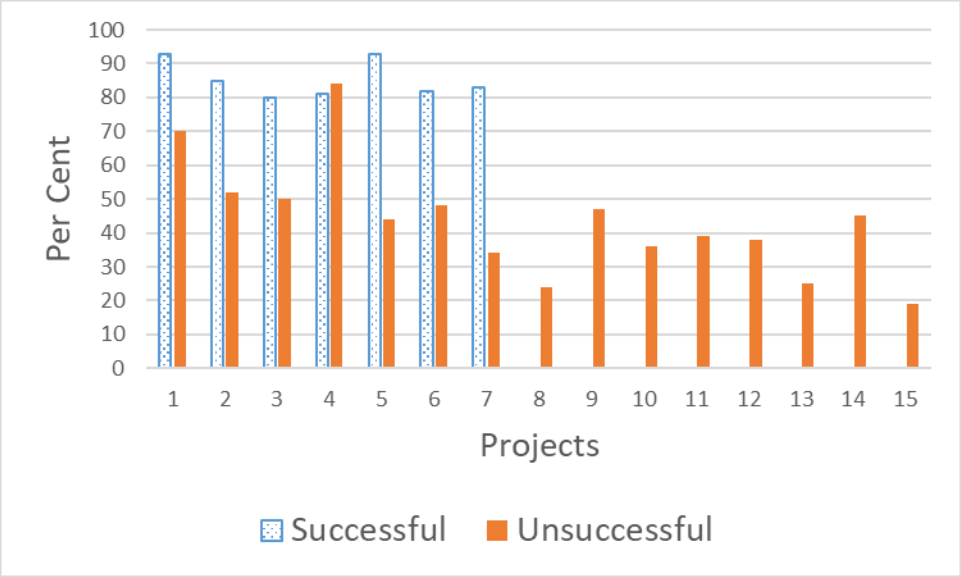

Figure 1. Summary of Checklist Results for Successful and Unsuccessful Projects

Table 4. Success Criteria used to evaluate projects.

Industry Involvement
Is the project led by industry
Are the commercial success criteria agreed by industry
Is the industry accountable for the success of the project
Does the Project Team have the right skills
Fishing
New product development
Market Research
Market development
Distribution
Exporting
Business analysis
Market Demand – Domestic
Will the retail price be competitive
Is the species recognised by consumers in the Australian market
Were consumers surveyed
Is there a plan for marketing - naming, labeling, presentation
Are end users (retailers, chefs) committed
Market Demand - Export
Has the importer been identified
Is the importer involved in the project
Is the industry participant experienced in exporting?
Product Format
Is this confirmed
If onboard or onshore processing required are facilities available
If product development is intended is there suitable technical and market input
Is shelf life adequate
Finances
Has a financial analysis been carried out by the industry participant?
If additional capital costs are required by the fisher or processor are funds available
Is the margin between price paid to fisher and retail price adequate
Supply Chain
Is supply of fish seasonally consistent
Is the volume of fish available adequate for the proposed market
Is quality of supplied fish satisfactory
Are distributers, wholesalers available and committed
Are all issues relating to storage on board, transport to market, overseas processing resolved
Fishing Regulations
Is unused quota available
If changes to regulations are needed is the regulator supportive
Fishing can proceed without further research on the fishery
Is the fishery regulator involved

Factors that Determined the Success Rate of Completed Projects

Through this process is was evident that to be commercially successful a project had to overcome most if not all the barriers. If the barriers could not be overcome in the planning stage, successful projects generally included an approach to overcoming the barrier in the project design. For example, in the development of value added products in conjunction with the end-users.

Insights gained from reviewing project reports and talking to project leaders are summarized below according to each group of success criteria.

Industry Involvement

A high level of industry involvement was necessary for projects to achieve commercial success, but it was not a guarantee. Four projects were initiated and led by commercial companies. The companies signed the funding agreement with FRDC (or the Seafood CRC) and most of the research in these projects was conducted by company staff, with some external assistance. However, as seen from the results shown in Table 5, only two of these projects was successful.

Table 5. Results of four projects initiated and led by commercial operators.

Project	Company	Outcome
2012-230 - Developing postharvest capability at the Lakes Entrance Fishermen's Co-operative.	Lakes Entrance Fishermen's Co-operative.	On site processing and product development enabled the Coop to establish a distribution arrangement with PFD and significantly lift returns per kg of Eastern School Whiting.
2013-237- Identification and development of the domestic and export market requirements for packaged pipis.	Goolwa Pipi Harvesters Association Incorporated	Market now established for chilled MAP pipis with 10 day shelf life
2007- 703 - Intervention strategies to maintain the safety and quality in a range of value added products made with under-utilised SESSF species.	Sydney Fish Market	Value added products introduced to market but not profitable.
2007- 209 -Adding value to an under-utilised fish species (Silver Warehou)	McLaughlin Consolidated Fishermen Ltd, and others	Product successfully developed for export but customer changed management and withdrew prior to export sales being achieved.

A series of subprojects conducted by Curtin University (2013-711) had substantial involvement by fishing companies, but the projects were generally initiated by the project leader, Dr Janet Howieson. The university managed the contract and was accountable for the outcomes. In this situation companies made important contributions to the project design, provided materials and conducted some of the research, resulting in three projects delivering commercial outcomes. But over half the companies participating in these subprojects did not always act on the research results in a timely, even though that had been involved in designing the research.

Nine projects delivered substantial technical success in the form of products or potential opportunities for underutilized species, but the results were not taken up by industry. In four of these projects there was minimal commercial involvement. These projects are shown in Table 6.

Table 6. Projects achieving technically success but no commercial uptake.

Project	Research Agency	Reason for lack of uptake
2013-711.30 Australian Salmon	Curtin University	Fishers not convince increased effort will be financially rewarding
2013-711.30 High pressure pasteurisation trials for seafood product	Curtin University	Commercial party lost interest, (but is now re-engaging).
2015-204: Realising economic returns of reducing waste through utilisation of discards in the GAB Trawl Sector of the SESSF.	Fishwell Consulting	Fishers did not follow through on commercial opportunities identified
2008-321 - Assessing the technology transfer and skills requirements for the introduction of mullet processing on the east coast similar to Shark Bay frozen sea mullet fillets	Clarence River Cooperative	Fishers were shown how commercial opportunities were created but did not follow through in their own business.
2010-774 Successful Sardines: Post harvest optimisation and new product development for human consumption	South Australian R&D institute	Products developed but the supply of suitably sized fish declined and the fishers had difficulty producing value added products..
2006-209 - Developing targeted strategies for improving product quality through selected low value seafood supply chains	University of Western Australia	Commercial operators not strongly engaged in the project.
1997-410 - Development of value added P products and preliminary marketing trials for Jack Mackerel	Australian Maritime College	Good products developed based on market research, but commercial operators not strongly engaged in the project
1992-125.24 Maximising economic returns in the NT Spanish Mackerel fishery	Queensland Dept of Agriculture and Fisheries	Commercial operators not strongly engaged in the project
1994-123 - Value adding to seafood by application of modern drying techniques.	Queensland Dept of Agriculture and Fisheries	Commercial operators not strongly engaged in the project

Skills of the Project Team

There were four projects in which the skills of the industry participants in project team may not have fully met the requirements of the project. These were 2007-703, 2010-774, 2008-321, 2007-245. In all cases there was industry participation, but the lesson learned was that commercial operators may not possess the knowledge required to conduct profitable seafood processing, product development and marketing, even though they claim to.

Market Demand

All of the commercially successful projects had a clear path to market identified before, or as part of, the project. This usually involved detailed consultation between the commercial project participant with end users as well as the wholesalers and distributors. Pricing was a key component of the market assessment, since the value of the fish was usually low, leaving little room for profit margins and return to the fisher.

Some projects conducted detailed consumer research that would have been useful to industry but was not used (for example 1997-410). During the period 1995-2000 the National Seafood Centre was supported by FRDC and attempted to stimulate demand for seafood through a range of programs, including production of marketing materials and information for the trade about the use of underutilized species (for example, the seafood catering manual). It has not been possible to judge the impact of those programs.

Product Format

Fourteen projects, including five commercially successful projects, involved research into value adding of underutilized species. The driver for product modification is likely to be the lack of market acceptance for the fresh product, or the need to transform the fresh product into one with a longer shelf life. The projects that did not succeed in this area did not involve industry or were unable to process the products profitably.

Finances

A fundamental problem with underutilized species is their low dollar value. Consequently, any attempts to exploit these species must work within narrow profit margins. The skill to be able to do this will generally lie in well established companies with pre-existing commercial supply networks. Most of this information is kept confidential and very little is to be found in the project reports. The exception is project 2015-204 by Ian Knuckey which contains very detailed information about volume and value of all the major species harvested in the Great Australian Bight. For example, while the fisher is paid $5.33/kg for a target species, Deepwater Flathead, only $1.46/kg is paid for Latchet, which is one of the largest volume underutilized species in the fishery. With a break even fishing cost of around $0.90/kg, there is little margin for error if Lachet was harvested. Additionally, the price for underutilized species is based on small tonnages reaching the market. A sudden increase in supply would decrease the price further.

Supply Chain

It is clear from the results of this study that projects aimed at improved exploitation of underutilized species are unlikely to be successful unless representatives of the whole supply chain are committed to the project. The best way to disrupt the non-productive cycle of low consumer demand and poor market prices leading to low prices paid to fishers and reduction in supply is to have all parties involved in trading the fish to be involved in the project.

The biggest supply chain issue was variation in supply. For example, new Australian Salmon products have been developed and markets identified by processors and retailers. However, both the variable quality and seasonality of supply prevents growth of this market. Few projects in this study involved exported fish but discussions with project leaders identified that the insufficient volume and variation in supply of underutilized species is a significant barrier to the Asian markets.

Fishing Regulations

Most of the projects in this study used fish that was available from existing quota or permits. The need for research into the fishery was not a limitation. This may not apply to all underutilized

species. For example, if the species is not currently harvested (for example, jellyfish in Victoria), or the full quota is not taken (Periwinkles in Tasmania) estimates of stock status and biology will be required to facilitate commercial exploitation.

Current Projects

Thirteen current projects were included in this study. Seven of these projects are concerned with regulation, management and harvesting of underutilized species in Australian oceans. The remaining six projects are concerned with commercial exploitation of underutilized species,

Table 7 summarises the objectives, proposed outputs and likely commercial outcomes from the current projects included in the study.

Only two of the projects concerned with commercial exploitation are led by, and contracted to, industry. One is a continuation of the successful research conducted by the Lakes Entrance Coop, involving processing and marketing of underutilized species. The other is a trade mission to Asia, looking for e-trade opportunities.

Project 2016-224 is of particular interest in the context of this study, because it involves detailed analysis of catch data and fishery profitability being conducted in conjunction with commercial operators. It also looks further at value adding underutilized species in cooperation with a commercial operator. The intention is to use action learning to encourage commercial operators to analyse the data and make the decision on whether or not to pursue underutilized species that might be fished profitably.

The success of the remaining commercial projects will depend on whether the commercial operators that are consulted as part of the project ultimately take up the results.

The seven current projects concerned with fishery management are all examining the economics and biology of underutilized fisheries. The general approach of these projects, which are mostly conducted by government agencies, is to identify the underutilized species that exist in sustainable numbers in the hope that commercial fishers will be encouraged to harvest them.

Table 7. Summary of Relevant Current FRDC Projects

Project	Cat.	Objectives	Summary of proposed outputs	Likely Commercial Outcomes
2016-214 - Identification of factors which impact on the profitability of individual GABTS operators and the fishery as a whole. PI: I Knuckey	FM	Taking into account outputs of FRDC Project 2015-204, identify a range of alternate business structures, and simulate economic performance	The project will help to identify cost savings and efficiencies through cooperation between fishers in processing, storage, fuel use, transport, marketing, fishing patterns, fleet dynamics, (seasonality, ports of operations, vessel size) and pooling of resources.	If the project can help fishers achieve efficiencies that reduce the cost of fishing, it may be more profitable for them to harvest underutilized species.
2017-023 Facilitating structural reform of South Australia's Marine Scalefish Fishery - identifying opportunities to develop under-utilised species. PI: A Fowler	FM	1. To assess the potential to diversify SA's Marine Scalefish Fishery by increasing production of currently under-utilised species, whilst conforming to the principles of ecologically sustainable development. 2. To provide advice about the potential to increase fishery catch for individual species in the commercial MSF fishery, and to provide guidance in each case with respect to the need for further research, economic development and regulatory reform	The fishery depends on four main species, which are all overfished and need revised management. There are 60 underutilized species in the fishery. The project will identify which of those might be suitable for commercial harvest with respect to biology, governance issues, and social and economic issues such as marketability.	Project is primarily about biology. Methods for assessing marketability appear to be by collective wisdom, not direct involvement of commercial operators. Could the approach be reversed and consider market options first?
2016-224 - Boosting fisher returns through smart value adding and greater use of	WSC	1. A demonstration to Australian fishers and enterprises of the increase in the harvest of non-utilised yield in wild fisheries	Output will be actual product produced and exported / reimported by Pacific West Foods and other commercial operators.	Action learning approach may increase the ability of commercial operators to assess

Project	Cat.	Objectives	Summary of proposed outputs	Likely Commercial Outcomes
underutilised species PI: E Colquhoun		2. A demonstration of an increase in the returns to fishers from fishery yield growth and value adding 3. A demonstration of increased utilisation, yield and margin of seafood product into value added formats for new consumer markets	Proposed approach is by action learning rather than have the project leader do all the analysis	profitability of underutilized species in future.
2016-207 - Development of post-harvest handling technologies for the under-utilised cross jurisdictional Royal Red Prawn fishery PI: S Poole	PMD	1. Establish the quality attributes of harvested deep water prawns 2. Determine post-harvest handling protocols that maximise quality 3. Develop product formats that address the demands of local and international consumers 4. Identify new markets to increase economic return within the fishery 5. Encourage adoption of best practice handling and potential market opportunities to industry members	Largely about new product formats that might expand range of potential export customers. Industry people involved at the end to find markets. Commercial operators involved but not leading or accountable. Is there a detailed business plan?	Market already exists. Not a new species. However, this project could increase utilization.
2015-202 - Maximising net economic returns from a multispecies fisher. PI: Sean Pascoe	FM	1. Development of a methodology for maximising net economic return to a multispecies fishery as a whole, and with regard to by-catch and discard species 2. Development of a framework to operationalise the methodology into	Developing strategies and targets for MEY in one fishery (SESSF) accessing many species including UUS.	This project will produce a decision tool that may aid in assessing profitability of underutilized species.

Project	Cat.	Objectives	Summary of proposed outputs	Likely Commercial Outcomes
		fisheries management objectives		
2015-225 - Developing and testing a multi-species, automated fish in-feed system for a production line to add-value and supply large local markets, replacing imports. PI: Dale Sumner	WSC	1. Develop and test an automated fish in-feed system, initially for use with school whiting. 2. Develop and test the in-feed system for other underutilised species.	Involves design and use of a grader to feed fish of various sizes into the filleting machine. Commercial operator leads the project and is accountable.	Will increase the number of species that can be added to the successful LEFCOL value added supply chain arrangement with PFD.
2016-056 What could Australia's total sustainable wild fisheries production be? PI: David Smith	FM	1. Develop a nationally agreed framework of methods to estimate sustainable yields. 2. Review and identify species that may have potential for significant growth in catches 3. Application of methods to determine potential total sustainable yield from Australian fisheries	The potential for increased catches of selected by-product and by-catch species will also be considered	A significant modelling exercise to assist regulators to identify underutilized species that might be biologically suitable for harvesting. Similar to 2017-023.
2016-146 - Understanding factors influencing undercaught TACs, declining catch rates and failure to recover for many quota species in the SESSF PI: I Knuckey	FM	1. Provide a range of papers with information on potential causes of undercaught TACs, declining catch rates and non-recovering species. 2. Develop strategies to address the undercaught TACs, decline in catch rates and non-recovering species	A very broad and detailed study, asking why catch rates of some UUS are declining.	Will provide hard commercial data on why certain species are not caught and what can be done about it.
2016-208 and 2017-050 - Waste to profit in urchin fisheries:	PMD	1. To determine the biochemical composition and volume of urchin	Provision of profitable end uses of urchins that make	Aims to turn a pest species into a useful product

Project	Cat.	Objectives	Summary of proposed outputs	Likely Commercial Outcomes
developing business opportunities to ensure fishery sustainability and safeguard reef dependent fisheries from destructive urchin grazing. PI: J Keane, S Osborne		waste and identify applications for the agricultural sector. 2. To assess the potential for using sea urchin as rock lobster bait.	harvesting them feasible.	
2015-200 - Guidelines on a tiered, risk-based approach to bycatch management. PI: S Nicol	FM	Develop and test guidelines for a tiered, risk-based framework for bycatch management where bycatch species are assessed and managed according to the level of interaction, the level of understanding and the risk of the impact of the interaction.	This project will develop and test a system for identifying bycatch species in each fishery, including the reclassification of bycatch as commercial species and vice versa.	Primarily concerned with fishery regulation and reporting.
2015-505 - Developing community supported fisheries in South Australia's small scale, multi-species, multi-gear fisheries. PI: J McPhail	FM	To ultimately foster an improved social licence to operate for the Lakes and Coorong Fishery (LCF) and Marine Scalefish Fishery (MSF) in South Australia.	This is a small project primarily about improving fishers' social licence through community involvement, using a technique shown to work in USA.	Improved social licence may prevent regulatory imposts that would cause a fishery to become underutilized.
2016-173 - Trade Mission: Creating a niche market for the supply of NSW Wild Caught mixed finfish to China through the GFresh B to B E-Commerce platform. PI: T Beattie	PMD	1. To conduct a trade mission to China to introduce representatives from the fishermen's cooperatives to the Chinese Seafood Market and discuss needs to deliver the quality and quantity required by the market. 2. Explore the potential of utilizing a E-	A major export challenge for NSW professional fishing companies has been the need to have large volumes of a single species that can be sold in bulk on commodity markets. The emergence of e-commerce platforms and the consequent shortening of the supply chain has	Asks the question whether e-trading in China can lift the profitability of small volumes of UUS.

Project	Cat.	Objectives	Summary of proposed outputs	Likely Commercial Outcomes
		commercial tool such as GFresh to supply the Chinese Seafood Market	created opportunities to develop niche markets for seafood products that have not been traditionally exported to China.	

DISCUSSION

Reasons for Underutilization

A fish species generally becomes underutilized in Australia for one or more of three reasons:

- Lack of market demand
- Low financial return to fishers does not warrant landing the fish
- Lack of regulatory approval or access to quota.

Poor market demand is due to:

- End-users (consumers, retailers and chefs) having limited knowledge and exposure to the species. For example, latchet, ocean jacket, and deep trawl species)
- End-users having perceptions of poor quality, texture or taste generally resulting from poor handling through the supply chain, particularly high oil content species.
- The need to process and add value to the fish to enable it to be stored, transported and retailed. For example, mullet and pilchards.
- Inconsistent volume and quality of supply, making it difficult to ensure product consistency for large volume buyers and exports.

Financial factors that mitigate against harvesting underutilized species include:

- Low prices paid to fishers for underutilized species.
- For a wild catch fishery targeting a high value species, the opportunity lost from catching low value species is commercially unsustainable. Returning to port with a substantial catch of fish for which there is a limited, low value market is not profitable, or of such small profit as to be not worth the effort.
- The costs of any additional processing, chilling or changes to fishing set up must be absorbed within the price margin between fisher and consumer.

Lack of regulatory approval was not a limitation in any of the projects included in this study, but could become an issue where quota holders do not release unused quota for reasons of competition.

Building Demand

The most significant of the three causes of underutilization described above is poor market demand. It is only by boosting demand that the fish will be purchased at a price and volume attractive to commercial fishers. Building demand for any consumer product is a costly exercise, that involves market research, product development, point of sale support, promotion, distribution and other factors specific to each product.

The decision to pursue or create a market is a business one that should be made by companies willing to take the risk. Companies with good networks and experience in processing, marketing and distribution are more likely to be successful. The decision needs to be based on financial analysis, using pricing and costing that is always held confidential by commercial operators.

Market research and development conducted by public sector agencies may assist in this process, but it should not be conducted in isolation, as the results can be too generic to be of value to the specific requirements of the commercial business. This was the case for many of the projects reviewed in this study. While the quality of the research is not disputed, there was not always a commercial operator primed to utilize the findings.

For the above reasons, it can be argued that any investment by FRDC in the exploitation of underutilized species should be conditional on a commercial fishing entity leading the project and being accountable for the outcome.

New Product Development

A significant proportion of the projects reviewed in this study involved the transformation of fresh fish into value-added products. These technological improvements may assist in bringing an underutilized species to market, as was the case in most of the successful projects, the best examples being the projects involving pipis (2013-237) and the Lakes Entrance Cooperative (2012-310). On a global scale, Surimi production is a good example of technology leading to increased utilization of low value species, with a global market estimated to be approximately 500,000tonnes

But the drive to introduce the new technology must come after confirmation that a market exists for the finished product. This study has shown clearly that new product development is more likely to succeed if it is driven by commercial operators who are involved in the market.

In addition, the commercial entity undertaking new product development should also have equipment and staff with the appropriate skills to conduct the research and continue production when the product is successful.

Fisheries Management

If demand for a species is secure and the price is right, history shows that fishers will find a way to harvest the species profitably. In this way fisheries move from underutilized to “new”. Examples include octopus in WA, Patagonian Toothfish, Periwinkles, and Orange Roughy. Once it becomes profitable to harvest an underutilized species, government and fishers have an incentive to study the fishery, and identify management arrangements that will ensure the fishery’s on going sustainability

However, some projects reviewed in this study where of a more exploratory nature, instigated by fishery managers wishing to identify underutilized species that might be exploited, based on biological findings and limited information about the market. While these projects generally involve some level of industry input, it is likely to be insufficient. This is based on the finding of this study, that commercial operators need to be fully engaged in creating demand for a new product if commercial outcomes to be achieved.

Some consideration could be given to reversing the process, so that investigation of the biology of the species only intensifies when a commercial opportunity has been established.

Commercial Operators Must Lead

A project that is led by a research agency, which is contractually accountable to FRDC for the outcome, may have enthusiastic, well-meaning commercial partners, but without the rigor of contractual and financial obligation it is too easy for the commercial operators to withdraw or reduce their input.

This issue is discussed in the final report from project 2013-711. After working on 42 species with many commercial operators, Dr Janet Howieson noted the following challenges when working with underutilized species:

- Commercial operators must be convinced that there will be an appropriate return on their efforts before they will participate, and this can be difficult to achieve.
- Involvement of the whole of supply chain involvement is essential.

- The volatile nature of commercial fishing means that commercial operators must occasionally redirect their resources away from the project, temporarily or permanently, causing delay or cancellation of the project. The contracts for these projects should therefore enable some flexibility.
- As a consequence of the point above, it might be preferable for FRDC contracts for these projects to have output rather than time based milestones.
- Every underutilized species brings its own challenges to the commercialisation process, and should be researched individually.

A potential solution to these challenges might be for the commercial operator to lead the project and be accountable for the outcome. It then becomes the operator's responsibility to renegotiate the contract with FRDC, and cover any costs in the event of a change to the work program.

Policy

In a world in which food security is uncertain for millions of people, the prospect of large tonnages of low cost protein being underutilized is something that naturally attracts the interest of policy makers.

The FAO Code of Conduct for Responsible Fisheries encourage nations to increase use of seafood. Australia invests resources in monitoring the extent of underutilized and maintains programs to assist fishers to reduce by-catch and interactions with non-target species.

However, in most fisheries there is a substantial catch of species which are not preferred by the market. Project 2015-204 identified that in the Great Australian Bight Trawl Sector, an average of 44 per cent of the total weight of the catch is discarded.

These fish are discarded because the complex economics associated with fishing rights, permits and quota arrangements in developed countries makes harvesting them unprofitable. As a consequence, the risk of attempting to build demand for the species is usually too high, and so the cycle continues. The species becomes known as "underutilized".

Policy initiatives to facilitate and encourage exploitation of underutilized species must therefore break into the cycle of poor profitability, either by helping create demand, subsidizing the cost of fishing or through legislation.

Of particular relevance in this context is new legislation called the Landing Obligation (or Discard Rule) implemented by the European Union under the Common Fisheries Policy to ensure all quota fish that are caught are not discarded. According to the SeaFish website, the landing obligation is "a complex piece of legislation and there is a great deal of uncertainty about how it will be implemented and what impacts it might have on seafood businesses." The legislation was introduced at the beginning of 2015 for pelagic species, requiring vessels catching pelagic species, such as mackerel and herring to land all fish caught. By 2019, the general rule is that no commercial fishing vessel can return any quota species of fish, of any size, to the sea once caught.

The reasons behind the new legislation are explained in a report issued by the European Parliament Directorate General for Internal Policies, called *The Landing Obligation and Its Implications on the Control of Fisheries*. http://www.nsrac.org/wp-content/uploads/2014/11/LO-Implications-on-Control.pdf

The report states use of over quota or undersize fish is:

…restricted to purposes other than direct human consumption, including fish meal, fish oil, pet food, food additives, pharmaceuticals and cosmetics. The expectation is that the landing requirement combined with the restriction to non-human consumption purposes will encourage fishers to internalise the costs of catching unwanted fish and motivate them to avoid unwanted catch, for example by altering their fishing practices. However, these measures can only go so far and unwanted catches will inevitably continue to occur. Consequently, Member States need to address the problem of how to manage these unwanted catches and how to control them once they have arrived in port.

A range of other publically funded approaches have been used to promote consumer acceptance and consumption of underutilized species. These are reviewed in project 2015-204 and include:

- The Iceland "bycatch bank"
- The "Fishing for the Markets" program in the UK.
- Use of discards for bait
- Distribution of bycatch species through hunger relief agencies in the USA.

A Role for FRDC

It should be noted that underutilization may just be a stage in a decades-long continuum of development of any fishery. There are commercially viable fisheries in existence now that did not exist thirty years ago. West Australian octopus and Patagonian Toothfish are examples. These fisheries developed when economic conditions were favourable for them to do so. Therefore, it is not suggested that FRDC should cease investing in projects involving underutilized species. Rather, the approach to these projects could be revised.

Before providing funds for a project that aims to exploit underutilized species, FRDC has had to judge the likelihood of commercial success of the project. It must do this with imperfect knowledge of the commercial situation. If the applicant is a research agency, the absence of commercial input is compounded. Yet, for the project to be successful it will need to involve a significant commercial operator than can establish and maintain a market for the new product. Therefore, it makes sense that as the primary beneficiary of the project, the commercial operator should lead it.

However, this study has shown that to be successful, projects must satisfy most of the success criteria identified. It is unlikely that the commercial operator will have all the skills and technologies essential for success of the project. There might be information or skill gaps at any point along the supply chain, for example, in market knowledge, product development, food safety, or project management.

It may therefore be appropriate for FRDC to provide the funds for research to fill those gaps. The funding should be provided as part of the contract to the commercial operator, with the research being done in-house or subcontracted to a research agency.

It is also important for FRDC to consider the opportunity cost of its investments and the likely benefits that will accrue for each investment. While there is undeniable economic benefit is facilitating the transition from an underutilized to a new fishery, the benefit in other circumstances could be questioned. For example, there have been numerous attempts over the past 20 years to increase the utilization of Australian Salmon. The database in Project 2013-711 shows average annual uncaught quota of Australian Salmon is 400t. If an FRDC project lifted the average beach price from $2/kg to $4/kg for the whole 400t, the increase in annual income to fishers would be $800,000, with costs to be deducted. On a national scale, this is hardly a significant effort.

Furthermore, if the price increase was $1 and it applied to ten percent of the unused quota, the annual benefit would only be $40,000.

It has not been possible to identify any cost benefit analyses that have been conducted on FRDC projects involving underutilized species. Results from such an analysis in future may assist FRDC in its investment decisions.

A Checklist to Assist in Design of Underutilized Species Projects

The list of success criteria provided in Table 4 could be provided by FRDC to applicants seeking funding for projects to exploit underutilized species. It may assist applicants to identify all the tasks required to ensure success.

CONCLUSION AND RECOMENDATIONS

Forty-two projects with a total value of $6.6million were reviewed. These included 30 completed projects and 12 current projects.

All projects but one achieved their technical objectives. However, only seven of the completed projects were successful in that they achieved a commercial outcome, or are likely to achieve one, defined as significant volumes of fish being regularly harvested and sold into a market consistently. This disparity is something that should be further investigated as it indicates that objectives and milestones of projects may not be rigorously assessed prior to approval.

Six of the seven commercially successful projects used a whole supply chain approach. This is a proven method of disrupting an entrenched cycle of low consumer demand and poor market prices leading to low prices paid to suppliers and reduction in supply. However, four unsuccessful projects also used this approach.

Thirteen projects were concerned with market and or product development. All these projects but one achieved their technical objectives, however there was little evidence of the results being taken up by the industry.

Twelve projects were primarily concerned with management of fisheries from a biological perspective. Three of these projects were ancillary to new fisheries, and two were concerned with fishing operations and profitability, while the remainder were initiated by regulatory agencies wishing to identify underutilized species that could be exploited commercially.

In addition to considering commercial success, some consideration must also be given to the impact of these projects on underutilization of fish generally. Underutilization is a global concern, with some fisheries, including some in Australia, discarding a third or more of their annual catch. This amounts to tens of thousands of tonnes of fish being wasted. This review found that the seven commercially successful projects had an impact on a scale of hundreds of tonnes of fish, rather than thousands of tonnes. They reflected successful commercialisation of a niche opportunity but are unlikely to produce a transformative impact on underutilized species at a national scale.

It is concluded that FRDC should consider revising its approach to research on underutilized species because:

- Despite the fact that all but one of the reviewed projects achieved their technical objectives, only seven were commercially successful.
- The scale of the successful projects was not transformational at a national level.
- The opportunity cost of these investments for FRDC needs consideration.

When considering investment in underutilized species in future, the following key factors must be considered:

- Tens of thousands of tonnes of underutilized species are discarded annually in Australia. Any transformational solution to this situation will require very significant changes.
- The fundamental problem with underutilized species for the Australian fishing industry is lack of market demand by domestic consumers.
- This means it is not profitable for Australian commercial fishers to harvest underutilized species.
- Attempting to change the economic equation by building demand in the domestic market is costly and high risk.

- The high cost structure of Australian fishing relative to export markets in Asia precludes access to those markets where there is a demand for low value fish.
- In light of the above, the decision to attempt exploitation of an underutilized species in the domestic or export market is a business one, likely to be based on low profit margins, that must be made by a commercial operator using their own data and networks.

The following recommendations are provided to assist FRDC and researchers in designing and implementing projects on this subject in future.

1. Projects should be initiated and led by a commercial operator (not an industry association) that signs the Funding Agreement with FRDC and is accountable for the outcomes.
2. Projects should be preceded by a financial analysis conducted by the commercial operator.
3. FRDC funds should only be used for research to fill knowledge gaps identified by the financial analysis.
4. If the research to fill the gaps is conducted by a public sector agency if should be subcontracted by the commercial operator, rather than FRDC.
5. Projects should only be approved when more than eighty per cent of the 34 success criteria in the checklist developed as part of this study are met.
6. These recommendations should also be applied to studies of the biology and status of underutilized species by fishery regulators that aim to identify species for commercial exploitation.

The conclusion of this review is that the FRDC investment of $6.6million over the past 25 years has achieved some useful, but not transformative results. A revised approach should therefore be considered.

Under current fishing policies in Australia, development of underutilized species could be easily regarded as primarily a commercial activity. As such, it is questionable whether FRDC has a role. Certainly there is justification for FRDC redirecting the investment to more cost effective areas.

A more important role for FRDC might be in the investigation of policy options that drive better utilization of underutilized species and the impact of those policies on the industry. Such policies have been implemented by the European Union and are the subject of considerable debate. It is likely that pressure will mount in Australia to implement similar policies.

SUPPLEMENTARY MATERIALS: EVALUATION OF ALL PROJECTS AGAINST SUCCESS CRITERIA

Supplementary Material Table 1. Evaluation of all Projects Against Success Criteria

Success Factors	2007-703 SFM	2012-230 LEFCOL	2013-711.30 Snapper	2013-711.30 Salmon	2013-711.30 Pilbara	2013-711.30 HPP
Industry Involvement						
Is the project led by industry	y	Y	N	N	N	N
Success criteria agreed by industry	Y	Y	Y	Y	Y	Y
Industry accountable for success	Y	Y	N	N	N	N
Does project team have skills in:						
Fishing	Y	Y	Y	Y	Y	Y
New product development	Y	Y	Y	Y		Y
Market Research	N	Y	Y	Y	Y	Y
Market development	N	N	N	N	N	N
Distribution	N	Y	Y	N	Y	Y
Exporting						
Business analysis	N	Y	Y	N	Y	N
Market Demand - Domestic						
Will the retail price be competitive	N	Y	Y	Y	Y	
Is species known by consumers	Y	Y	Y	Y	Y	N
Were consumers surveyed	N	Y	Y	Y	N	Y
Is there a plan for marketing	Y	Y	Y	Y	N	N
Are end users (retailers) committed	N	N	N	N	Y	N
Market Demand - Export						
Has the importer been identified						
Is the importer involved						
Is team experienced in exporting						
Product Format						
Is this confirmed	Y	Y	Y	Y	Y	N
IAre processing facilities available	Y	Y	Y	Y	Y	Y
Tech and market input to NPD	Y	Y	Y	Y		N
Is shelf life adequate	Y	Y	Y	N	Y	N
Finances						
Financial analysis completed	N	Y	Y	N	Y	N
If capital needed is it available	Y	Y	Y	N		Y
Is price margin adequate	Y	Y	Y	Y	Y	Y
Supply Chain						
Is fish supply consistent	Y	Y	Y	N	Y	Y
Is volume of fish adequate	Y	Y	Y	N	Y	Y
Is quality of fish satisfactory	Y	Y	Y	N	Y	Y
Are distributers, etc committed	N	Y	Y	Y	Y	N
Is storage and transport satisfactory	Y	Y	Y	N	Y	N
Fishing Regulations						
Is unused quota available	Y	Y	Y	Y	Y	Y
Is the regulator supportive						
Is research on the fishery needed	Y	Y	Y	Y	Y	Y
Is the fishery regulator involved						
SCORE (No of Y)	19	26	23	14	20	13
COMMERCIAL SUCCESS	**N**	**Y**	**Y**	**N**	**Y**	**N**
PER CENT YES	**70%**	**93%**	**85%**	**52%**	**80%**	**50%**

Supplementary Material Table 1. Evaluation

	Project						
Success Factors	**2013-711.40 Scampi**	**2013-237 Pipis**	**2007-209 Silver Warehou**	**2010-706 Blue swim Crab**	**2015-204 GAB**	**2008-321 Clarence**	**2010-774 Sardines**
Industry Involvement							
Is the project led by industry	N	Y	Y	N	N	Y	N
Success criteria agreed by industry	Y	Y	Y	Y	N	Y	N
Industry accountable for success	N	Y	Y	N	N	Y	N
Does project team have skills in:							
Fishing	Y	Y	Y	Y	Y	Y	Y
New product development	Y	Y	Y	Y	N	N	N
Market Research	Y	Y	Y	Y	N	N	N
Market development	Y	Y	Y	Y	N	N	N
Distribution	Y		Y	Y	Y	Y	N
Exporting			Y				N
Business analysis	N	Y	Y	Y	Y	Y	N
Market Demand - Domestic							
Will the retail price be competitive		Y	Y	Y	N	N	N
Is species known by consumers	N	Y	N	Y	N	Y	Y
Were consumers surveyed	Y	N	N	Y	N	N	N
Is there a plan for marketing	Y	Y	Y	Y	N	N	Y
Are end users (retailers) committed	Y	Y	Y	N	N	N	N
Market Demand - Export							
Has the importer been identified			Y				
Is the importer involved			Y				
Is team experienced in exporting			Y				
Product Format							
Is this confirmed	Y	Y	Y	N	Y	N	N
IAre processing facilities available	Y	Y	Y	Y		N	Y
Tech and market input to NPD	Y	Y	N	Y		N	Y
Is shelf life adequate	Y	Y	Y	Y	Y	Y	Y
Finances							
Financial analysis completed	N	Y	Y	Y	Y	N	N
If capital needed is it available	Y	Y	Y	Y			Y
Is price margin adequate	Y	Y	Y	Y	N	Y	Y
Supply Chain							
Is fish supply consistent	Y	N	Y	Y	N	N	N
Is volume of fish adequate	Y	Y	Y	Y	Y	Y	N
Is quality of fish satisfactory	Y	Y	Y	Y	Y	Y	N
Are distributers, etc committed	Y	Y	N	N	N	N	N
Is storage and transport satisfactory	Y	Y	N	Y	Y	N	N
Fishing Regulations							
Is unused quota available	Y	Y	Y	Y	Y	Y	Y
Is the regulator supportive							
Is research on the fishery needed	Y	Y	Y	Y	Y	Y	Y
Is the fishery regulator involved							
SCORE (No of Y)	22	25	27	23	11	13	10
COMMERCIAL SUCCESS	**Y**	**Y**	**N**	**Y**	**N**	**N**	**N**
PER CENT YES	**81%**	**93%**	**84%**	**82%**	**44%**	**48%**	**34%**

Supplementary Material Table 1. Evaluation

Success Factors	2006-209 Supply chain	1997-410 Jack Mackerel	2007-245 Soft Shell Crabs	1992-125 Spanish Mackeral	1994-123 Drying	Various 2002-250 Biophos	2012-207 Bioactives
Industry Involvement							
Is the project led by industry	N	N	N	N	N	Y	N
Success criteria agreed by industry	N	N	Y	N	N	Y	N
Industry accountable for success	N	N	N	N	N	Y	N
Does project team have skills in:							
Fishing	Y	Y		Y	N	Y	Y
New product development	N	Y	Y	Y	Y	N	N
Market Research	Y	Y		N	Y	Y	N
Market development	N	N		N	N	N	N
Distribution	N	N		N	N	Y	N
Exporting	N	N		N	N		N
Business analysis	N	Y	N	N	N	Y	N
Market Demand - Domestic							
Will the retail price be competitive	N	Y	Y	Y	Y	Y	Y
Is species known by consumers	Y	N	Y	Y	Y		Y
Were consumers surveyed	N	Y	N	N	N		N
Is there a plan for marketing	N	N	N	N	N	Y	N
Are end users (retailers) committed	N	N	N	N	N		N
Market Demand - Export							
Has the importer been identified		N		N	N		
Is the importer involved		N		N	N		
Is team experienced in exporting		N		N	N		
Product Format							
Is this confirmed	N	Y	N	Y	Y	Y	N
IAre processing facilities available	N	N	N	Y	N	Y	N
Tech and market input to NPD	N	Y	Y		Y	Y	N
Is shelf life adequate	Y	Y	N	Y	Y	Y	
Finances							
Financial analysis completed	N	N	N	N	N	Y	N
If capital needed is it available	N	N	Y	N	N	Y	
Is price margin adequate	N	Y	Y	Y	Y	Y	
Supply Chain							
Is fish supply consistent	N	Y	N	Y	N	N	Y
Is volume of fish adequate	Y	Y	N	Y	Y	N	Y
Is quality of fish satisfactory	N	Y	Y	N	Y	Y	Y
Are distributers, etc committed	N	N	N	N	N	Y	N
Is storage and transport satisfactory	N	N	N	N	N	Y	N
Fishing Regulations							
Is unused quota available	Y	Y		Y	Y		
Is the regulator supportive							
Is research on the fishery needed	Y	Y		Y	Y		
Is the fishery regulator involved							
SCORE (No of Y)	7	15	8	12	12	19	6
COMMERCIAL SUCCESS	**N**	**N**	**N**	**N**	**N**	**Y**	**N**
PER CENT YES	**24%**	**47%**	**36%**	**39%**	**38%**	**83%**	**25%**

Supplementary Material Table 1. Evaluation

Success Factors	2011-024 Periwinkle	1992-125 1999-138 Jellyfish
Industry Involvement		
Is the project led by industry	N	N
Success criteria agreed by industry	N	N
Industry accountable for success	N	N
Does project team have skills in:		
Fishing	Y	Y
New product development	N	N
Market Research	N	N
Market development	N	N
Distribution	N	N
Exporting	N	N
Business analysis	N	N
Market Demand - Domestic		
Will the retail price be competitive	Y	Y
Is species known by consumers	Y	N
Were consumers surveyed	N	N
Is there a plan for marketing	N	N
Are end users (retailers) committed	Y	N
Market Demand - Export		
Has the importer been identified	Y	N
Is the importer involved	N	N
Is team experienced in exporting	N	N
Product Format		
Is this confirmed	Y	N
IAre processing facilities available		N
Tech and market input to NPD		N
Is shelf life adequate	Y	N
Finances		
Financial analysis completed	N	N
If capital needed is it available		N
Is price margin adequate	Y	Y
Supply Chain		
Is fish supply consistent	N	N
Is volume of fish adequate	Y	N
Is quality of fish satisfactory	Y	Y
Are distributers, etc committed	N	N
Is storage and transport satisfactory	Y	N
Fishing Regulations		
Is unused quota available	Y	N
Is the regulator supportive		Y
Is research on the fishery needed	Y	N
Is the fishery regulator involved		Y
SCORE (No of Y)	13	6
COMMERCIAL SUCCESS	**N**	**N**
PER CENT YES	**45%**	**19%**

PART 2: COMMERCIAL AND FISHERIES MANAGEMENT CONCEPTS THAT INFLUENCE SUPPLY AND DEMAND OF UNDERUTILISED SPECIES

PART TWO: EXECUTIVE SUMMARY

Catching unwanted fish species is an unavoidable consequence of commercial fishing. Some of this fish is bought from fishers at very low prices and used for low value products but the bulk of it is discarded at sea.

Many improvements have been made to fishing gear to reduce fishing bycatch, however there are still large volumes of underutilised species caught. Apart from some niche products, little of this product that is landed reaches wholesale and retail food markets because there is lack of demand for it, further complicated by failures in the supply chain. Most of the landed product is diverted to pet food, bait, and rendering for fish meal and oil.

This study was commissioned by FRDC to investigate the factors that influence supply and demand of underutilised species, and to better understand the potentially competing objectives of public policies aimed at minimizing fish discards and commercial drivers that limit the harvest of underutilized species.

It was found that Australia produces approximately 50,000t of underutilised species per annum. The trawl fisheries produce the biggest proportion, comprising a wide range of species.

The reasons why there is limited retail demand for these fish are known and include unreliable supply; poor quality; consumer unfamiliarity with the species; and in some cases, lack of wholesaler knowledge about the availability of each species. Supply is inhibited by low prices paid to fishers; high processing costs for low yielding species; competition for hold storage space onboard and regulatory restrictions on catch levels.

Factors that might be used to increase demand include a lower retail price than icon species; increased community interest in waste reduction; market demand in Asia; growth in domestic ethnic populations; interest from high profile chefs; local provenance; and the emergence of some quality products that can change consumers' perceptions.

Funding requests to support development of new products from underutilised species are occasionally received by FRDC. Part One of the report made recommendations about how these projects could be structured in future and provided a check list to assist in determining whether projects were likely to achieve the desired commercial outcomes. The most significant recommendation was that the projects should be led by entrepreneurial commercial operators.

Entrepreneurial individuals are operating in this space and examples are provided in this report. Therefore, it could be argued that market forces will gradually reduce the volume of underutilised species and FRDC investment in the area has little justification.

However, these entrepreneurs are rare. To date, these initiatives have not created sufficient demand to encourage food service suppliers, wholesalers and supermarkets to drive major change in the supply chain. There is a counter argument for FRDC to use R&D levies collected from fishers to assist in building linkages between each stage of the supply chain.

Constructive dialogue about new seafood opportunities between retailers, food service providers, wholesalers, processors and fishers is difficult to establish. A solution to this situation might be for FRDC to employ a full time program manager with expertise in food service and retailing. To test this proposition, it is recommended that:

1. FRDC establishes a three-year trial appointment of a project manager who can build lines of communication with the food service/retail sector. The manager could also assist in identification of entrepreneurs, building networks, project design, cost sharing between companies, technical issues and sourcing funds for projects.

Some of the people behind the successful initiatives mentioned in this report might be willing to contribute their experience to the greater good. The new manager could work with these people to identify further opportunities. It is recommended that:

2. An informal group of underutilised species innovators is established to work with FRDC to develop ideas for overcoming supply chain blockages and identify new opportunities.

There are situations where fishery regulations drive a species into the underutilised category, either by preventing their catch or requiring fish to be discarded at sea. This is generally the result of trade-offs that must be made between ecological, recreational and commercial interests. Such issues are localised and need to be solved at a local level.

The Australian fishing industry does not need to tackle the problem of underutilised species alone. The *DiscardLess* R&D program, established by the European Commission to assist implementation of the new Landing Obligation regulations, may be a valuable source of innovative ideas that could be adopted by Australian companies. It is therefore recommended that:

3. FRDC establishes formal and personal links with international programs such as the European Union *DiscardLess* research program, with a view to transferring to the Australian industry any novel concepts for avoiding underutilised species and effective use of those species that are caught.

In some counties seafood waste and underutilised species are used to extract fine chemicals. This opportunity in Australia is limited by the absence of commercial expertise in the area. If FRDC is to explore this area further it would be advisable to engage the services of a person, likely from overseas, experienced in commercial fine chemical extraction from seafood. A recommendation for FRDC to consider is:

4. Any investigation of the use of underutilised species for fine chemical extraction should be preceded by an investigation conducted by a person with commercial experience in the process.

Given that the problem of underutilised species is largely one of limited market demand, some activity in the area of market development is warranted. Simply increasing buyers' awareness of the range, tonnage and seasonality of currently underutilised species available from each fishery would be of value. Currently this information is not made public, which puts potential new entrants and investors at a disadvantage, particularly export customers. It is recommended that:

5. FRDC produces a tabulated summary of tonnage and seasonality of underutilised species available in each Australian fishery with a description of the eating quality and processing attributes of each species. This should be made available to the food service industry and to seafood importers and exporters.

Market demand can also be improved by promotion. Individual fisheries, associations and chefs are conducting limited promotions and wherever possible these should be supported and expanded. FRDC could also attempt to coordinate these activities to achieve greater impact. It is recommended that:

6. Within its legislated constraints, FRDC should seek opportunities to assist industry conduct market development and public awareness activity in support of expanded use of underutilised species.

It is hoped that the above recommendations will assist some entrepreneurial companies develop new markets for underutilised species. However, major improvement in the way fishers and the food industry see underutilised species is likely to need more transformational, disruptive change.

A new approach with a completely different mindset might be more productive. The application of Design Thinking to bring about change in complex systems should be considered. In these systems it is essential that commitment about future directions is achieved by bringing together and aligning the interests of different stakeholders who will be impacted by the project and/or who have the ability to themselves impact project outcomes. This approach may be particularly relevant for industry challenges such as underutilised species, where the ultimate opportunity is apparent to all but dysfunctionality of the current supply chain prevents realization of the opportunity. Therefore, it is recommended that:

7. FRDC conducts a case study on underutilised species using Design Thinking to achieve supply chain innovations that may ultimately lead to transformative improvements of benefit to key participants.

INTRODUCTION

This project is timely. It comes at a time when many people concerned with seafood are interested in underutilised species. This interest probably derives from several sources. Food security and food waste have become front of mind concerns of many consumers and some high profile chefs are promoting the use of underutilised species. Also, the growing ethnic population of Australia sees these species through more appreciative eyes. At a regulatory level, new Commonwealth Fisheries Harvest Strategy and Bycatch policies were released in 2017 and in 2015 the European Union moved to reduce bycatch by introducing legislation requiring compulsory landing of all quota species caught. Supply still vastly outweighs demand, but fishers are bringing some underutilised or secondary species to market more often.

The prospect that thousands of tonnes of edible fish is going to waste when it could be used as a rich nutritional resource is perplexing. But there are numerous reasons why these fish are not currently exploited commercially. These reasons may be related to consumer preferences, fishing processes, regulation, fisher competitive behavior, quality and supply chain arrangements.

Over the past 25 years, the Fisheries Research and Development Corporation (FRDC) has supported numerous projects that sought to investigate commercial opportunities for the use of currently underutilised wild-caught fish species. Forty-two of these projects with total grant funding of $6.6million were reviewed and the results reported in Part One of this project.

It was found that while most projects achieved their technical objectives, and some achieved successful commercialisation of a niche opportunity, none produced a transformative impact on underutilised species at a national scale.

To help improve this situation, Part One of this report contained recommendations and a checklist to be used by project applicants and FRDC staff to design future projects.

But while it is hoped these recommendations will be helpful, the underlying problem is a lack of consumer demand for a large proportion of the underutilised species caught in Australia. Where there is some demand, disconnections in the supply chain appeared to limit its commercial exploitation.

Consequently, the project was expanded to identify in more detail the factors that influence supply and demand for underutilised species.

Objectives

The objectives of this project are:

1. Identification of commercial factors and fisheries management policy concepts that might influence future supply and demand of underutilised species in Australia.

METHODS

Following a scan of the relevant literature on the subject of underutilised seafood , face to face interviews were conducted with 44 people representing most points in the seafood supply chain. This included commercial fishers, processors, food service personnel, fisheries managers, industry associations and researchers from many parts of Australia.

A list of people interviewed is provided in Appendix 1.

FRDC has previously conducted some very detailed studies of this area and the Principal Investigators of those projects were consulted. These projects included:

Koopman, M *et al*	2015-204	Realising economic returns of reducing waste through utilization of discards in the GAB Trawl Sector of the SESSF
Kennelly, S	2015-208	Developing a National Bycatch Reporting System
Howieson, J	2013-711.30	Seafood CRC: new opportunities for underutilised species

Four related projects supported by FRDC are ongoing. The Principal Investigators of these projects were also consulted:

Knuckey, I	2016-146	Understanding factors influencing undercaught TACs, declining catch rates, and failure to recover for many quota species in the SESSF.
Knuckey, I	2016-214	Identification of factors which impact on the probability of individual GABTS operators and the fishery as a whole.
Colquhoun, E	2016-224	Boosting fisher returns through smart value adding and greater use of underutilised species
Fowler, A	2017-023	Facilitating structural reform of South Australia's Marine Scalefish Fishery - identifying opportunities to develop under-utilised species

RESULTS

Underutilisation of food in general

> *Neglected and Underutilised Species are those species with under-exploited potential for contributing to food security, health (nutritional/ medicinal), income generation, and environmental services. (Food and Agriculture Organisation).*

Underutilisation is not confined to seafood. In 2001 the Food and Agriculture Organisation (FAO) established the Global Facilitation Unit for Underutilised Species, in response to concerns that over 50% of humankind's requirements for protein and calories are now met by three crops - maize, wheat and rice. Just thirty plant species provide 95% of the world's food energy needs. The concern for FAO is that the narrowing base of global food supply limits livelihood options for the poor, and possibly small businesses.

The Unit is primarily concerned with crops, but the principles espoused by it are common to food in general. In its report called *Promoting Value Chains of Neglected and Underutilised Species* (Will 2008), a list is provided of common features of underutilised species, many of which are readily adaptable to seafood:

- important in local consumption and production systems
- highly adapted to agro-ecological niches and marginal areas
- ignored by policy-makers and excluded from R&D agendas
- represented by wild species, ecotypes and landraces
- cultivated and utilised drawing on indigenous knowledge
- scientific information and knowledge about underutilised species are scant
- their current use is limited relative to their economic potential.

It concluded that the main common characteristic of underutilised species is that their commercial potential and the knowledge of how to utilise this potential in a competitive environment are ignored:

- **by research:** overlooking the need for science-based knowledge development, e.g. into traditional uses and indigenous knowledge, development of new products and appropriate technologies;
- **by policy-makers:** failing to orient sector development policies towards biodiversity conservation, and poverty reduction policies towards the development of the economic potential of underutilised species for the poor;
- **by public and private stakeholders:** dismissing conservation efforts as a non-economic task predominantly postulated by environmentalists (green movement); and last, but not least, and
- **by supply chain operators (producers, processors, traders, consumers):** failing to recognize the commercial potential, and hence the possible economic benefits.

Definition of underutilised fish species

The Commonwealth Fisheries Harvest Strategy Policy (DAWR 2017) categorizes fish species as follows:

Key commercial – Species that are almost always retained and landed and make a significant contribution to the value of the catch in a fishery. Because of their value, more resources are generally directed to the assessment, management and monitoring of these species, and there is often a relatively high level of data available for these stocks.

Secondary commercial – Species that make some contribution to the value of the catch in a fishery, but are not the most valuable species caught in a fishery. They are usually retained and landed.

Byproduct – Species that make a minor contribution to the value of the catch in a fishery. They are occasionally landed and retained—ranging from rarely encountered and usually retained, to frequently encountered and rarely retained. There is often limited biological or economic information available for byproduct stocks or species.

Bycatch – Species that are not usually retained. They make no contribution to the economic value of the fishery.

Underutilised species can be found in any of these categories. For example, it is often the case that the full quota or allowable catch of key commercial species are not landed. Secondary commercial species make up a significant proportion of underutilised species because the market for them is unreliable. Byproduct and bycatch species are generally all underutilised.

Underutilised fish species can therefore include the following:

A. Fish that are caught, but not used for human consumption. These fish are returned to the sea (discarded) or used for low value products – e.g. fertilizer, bait.
B. Fish that are not caught even though quota is available or permits to harvest have been issued.
C. Fish that are neither caught nor included in current licensing arrangement, yet might be caught in sustainable quantities.

Although all classes of underutilised species are considered in this report, the primary emphasis is on those species that are caught and discarded. The European Union refers to these as “unwanted and unavoidable catches”.

Extent of the problem

Underutilisation of wild caught fish occurs globally and is an unavoidable consequence of commercial fishing.

Most fisheries have some form of bycatch reduction policy that aims to reduce the volume of fish that is caught and discarded at sea. This is driven not only by a desire to reduce waste, but to also aid in fisheries management. Knowledge of the harvest tonnage of a given species that is returned dead to the sea adds to the information available to determine the total allowable catch for that species. The first bycatch policy for the Commonwealth Fishery, which covers more than 2,000 species, was released in the year 2000 and a revised consultation draft is now available (DAWR 2017). Guidelines for handling bycatch and returning it to sea as quickly as possible to minimize fish mortality are also available. Improved design of fishing gear has resulted in considerable reduction of bycatch over the past decade. (AFMA 2016).

In most countries the effort to collect data on the extent of bycatch is sporadic and does not match the rhetoric of the policies. This is due to the difficulty of categorizing tonnes of often highly diverse fish into species or key aggregated groups and weighing them at sea before they are discarded. Also, the proportion of a catch that is bycatch varies greatly according to the fishing techniques used, with proportions highest in trawling and lowest in line fishing and hand collection.

In its last survey, conducted in 2004, the FAO estimated the global volume of underutilised species to be 7.3 million tonnes. Most nations have pledged to reduce this. The total global marine harvest of fish is 79.3 million tonnes (2016 data). An attempt to recalculate the level of discards in 2015 was abandoned due to the difficulty and unreliability of data collection. It is generally thought ten to fifteen per cent of the total marine catch is discarded (FAO 2018).

An exception is the USA which has a well-developed bycatch reporting system. The National Marine Fisheries Service publishes reports on bycatch estimates, with the latest published in 2016. Based on 2013 figures, bycatch was estimated to be 689 million pounds (0.31 million tonnes) compared to total landings of 6.1 billion pounds. (2.77 million tonnes) (Benaka 2016).

In Europe, where the Landing Obligation was initiated in 2015 specifically to reduce bycatch (see below) the level of discards varies widely across fisheries. Against a total annual production of 5 million tonnes in 2015, discards in the Mediterranean Sea were ten percent and "significantly higher" in the North East Atlantic Ocean (Guillen 2018).

Australia does not have a national discards reporting system but one is under development with funding from FRDC (Kennelly 2018). This study provides a comprehensive explanation of the complex systems and assumptions used for assembling data on bycatch. Data has been collected from three states, and the Northern Territory (Table 1) with data from the remaining States to be collected over the coming year.

Table 1. Discards as a proportion of total catch in four Jurisdictions (Kennelly 2018)

State	Retained Catch (t)	Discards (t)	Discards as % of Total
New South Wales	13,155	6,464	33%
Tasmania	5,199	2,529	33%
Queensland	19,261	26,579	58%
Northern Territory	5,198	855	14%
TOTAL	**42,813**	**36,427**	**46%**

For Commonwealth Fisheries, the Australian Fisheries Management Authority provided data for 36 quota species in the Southern and Eastern Scalefish and Shark Fishery (SESSF) (Day 2018). The weighted average of discards over the four years 2013 to 2016 was approx. 1,550t, or 9.4% of the 16,500t total catch in that fishery.

A study of bycatch utilisation in the Great Australian Bight Trawl Fishery (GABTF) found that 2,436t of catch was retained and 2,311t (49%)was discarded (Koopman 2017).

These studies collectively account for 40,000t of discards. Discards from Western Australia, Victoria, and additional fisheries in South Austarlia and the Commonwealth could easily account for another 10,000t. The volume of bycatch discarded each year in Australian fisheries is therefore likely to exceed 50,000t.

Species of fish that are underutilised

There is a very broad range of species that can fall into the underutilised category, reflective of the diversity of species that interact with Australian fisheries, the broad geographic spread of these fisheries (e.g. tropical to sub-Antarctic), and the diversity of gear types employed. To gain a clearer picture of what constitutes an underutilised species, it is necessary to look at individual fisheries within jurisdictions. For example, in the figures reported in Table 1 for Tasmania 87% of the discards were Southern Rock Lobster (*Jasus edwardsii*) and in the Commonwealth Fishery, 49% of the discards were Blue Grenadier (*Macruronus novaezelandiae*) – these are 'key commercial' and 'secondary' species respectively. In Queensland and New South Wales more than half the discards came from prawn trawling, although it should be noted that there has been considerable success in reducing bycatch from prawn trawling (AFMA 2017).

Current and past studies supported by FRDC have examined discards in specific fisheries to identify those species most suited to value adding.

The most comprehensive of these studies (Koopman 2017) investigated the fate of 35 species or species groups in the GABTF. A table from that report that shows the volume of catch retained and discarded for each species is in Appendix 2. The key commercial species for this fishery are Deepwater Flathead (*Platycephalus conatus*) and Bight Redfish (*Centroberyx gerrardi*), which together account for 57% of the retained catch. An additional 17 secondary species that are generally retained accounted for 17% of the retained catch. The remaining 26% of the retained catch was composed of 16 species, that were occasionally retained, but more often discarded. These are the underutilised species that make up nearly all of the discards. One species, Latchet, (*Pterygotrigla* spp.), made up 34% (780t) of the discards. Skates, rays, dogfish and stingarees made up a further 44% (1,023t) of the discards. Some latchet is sold in retail seafood stores and 62t was retained for this purpose. It has very good taste and texture, but the large head makes it hard to fillet and the yield of fillets is low.

The final report of the project on Australian discard reporting (Kennelly 2018) contains groupings of species that are discarded in the four jurisdictions studied. These are provided in Appendix 3.

As part of the Seafood CRC, Curtin University undertook a major investigation of alternative uses for underutilised species (Howieson 2017). This work began with preparation of a database of underutilised species, primarily from Western Australia fisheries, that includes comments on availability, processing and market potential. The database can be found in Appendix 4.

A current FRDC study is working with fishers and processors in New South Wales and Tasmania to identify opportunities for enterprises to increase the harvest of underutilised species for use in production of value added formats for new consumer markets (Colquhoun 2017). Detailed investigation identified twelve underutilised species, six of which have commercial potential. These six species could provide an additional 5,000t of fish with an estimated GVP of $31million. The species identified were Royal Red Prawn, (*Haliporoides sibogae*), squid, Australian Sardine (*Sardinops sagax*), Ribbon Fish Blue Mackerel (*Scomber australasicus*), and Yellowtail Scad (*Trachurus novaezelandiae*). This project is ongoing and the activities are commercial in confidence.

In an alternative approach, the Department of Primary Industries and Resources in South Australia (PIRSA) is examining the South Australian Marine Scale Fishery (MSF) to identify opportunities to develop underutilised species (Fowler 2017). Currently the MSF depends on four main species, being King George Whiting (*Sillaginodes punctatus*), Snapper (*Chrysophrys auratus*), Southern Garfish (*Hyporhamphus melanochir*) and Southern Calamari (*Sepioteuthis australis*), all of which

experience varying degrees of commercial and recreational fishing pressure that has prompted the need for a revision of current MSF management planning. There are 60 underutilised species in the MSF. The project will identify which of those might be suitable for commercial harvest from the fishery manager's perspective, with respect to biology, governance issues, and social and economic issues. The project is in its initial stages at the time of writing and is due for completion in 2019.

All the trawl fisheries in Australian waters catch an abundance of species. Apart from the key commercial species caught in the trawl, there are many other secondary species that are underutilised to various degrees. Identification of the species most suitable for commercial development requires a detailed look at individual fisheries, in conjunction with the fishers, who are the primary people who have knowledge of likely tonnage, seasonality and cost of harvesting. This situation will be improved through regular temporal and spatial reporting of discarded fish according to species or family group, at a minimum.

Factors influencing domestic supply and demand

Fishers prefer to sell their catches for human consumption if possible, as it is the most profitable outcome. Currently, the highest value market for underutilised species is in fresh and frozen fillets, but the size of the market is small. Whole, fresh fish are also sold into the domestic market and frozen whole fish are exported. A considerable volume of underutilised species is used for pet food, bait and fertilizer.

In their detailed study of underutilised species in the Great Australian Bight Trawl fishery, Koopman et al (2017) conducted an extensive review of the literature on factors affecting supply and demand of underutilised species. Anyone interested in this subject is urged to read their comprehensive report, which includes and extensive list of known barriers to the use of bycatch. The report also gives many examples of solutions developed overseas to address each category of supply and demand barrier.

With that report as background, the following analysis describes the barriers and opportunities associated with underutilised species that were described during detailed discussions with people involved in numerous Australian fisheries at all levels of the supply chain.

Positive demand factors

Retail Price

Any study of supply and demand in the Australian seafood industry is severely constrained by the absence of data. While data on price and volume trends for Australian seafood must be available to supermarkets, foodservice and wholesalers the data is closely held and never made public. Consequently, it is not possible to know the volume or value of underutilised species sold in Australia. This is further complicated by the lack of robust species-level catch data on underutilised species, as these species are generally aggregated up to a family group (for example) for reporting purposes

However, it is possible to draw some conclusions about market dynamics by looking at retail prices of fresh and thawed fillets at supermarkets. Table 2 sets out four arbitrary price categories for analysis.

Table 2. Supermarket retail price categories for fresh and frozen fillets.

Price /kg	Example Species
More than $35/kg	Flathead, King George Whiting, Barramundi, Red Emperor
$25 -$35 kg	Atlantic Salmon, swordfish, Ling, Saddletail Snapper, Grey Mackerel
$15 - $25/kg	Mullet, Bream, Herring
Less than $15/kg	Imported frozen fillets; i.e. New Zealand Hoki, Nile Perch, Vietnamese Basa

The prices shown for species in Table 2 are generalized based on the author's experiences in travelling to undertake the interviews as part of this project, and do not take account for seasonality of catch or specials. It is also worth noting that some iconic species such as King George Whiting frequently retail for more than $50/kg.

The key points to be drawn from the table are:

- When buying fresh fillets (as compared to packaged seafood) many consumers prefer to buy iconic species that they recognize and are willing to pay high prices for them.
- Aquaculture produced Atlantic Salmon (*Salmo salar*), due to its ubiquitous availability, sets a benchmark price for fresh fillets at $28 - $30/kg and some other wild caught, popular species can compete with it in the $25 to $35 range.
- Fish fillets that are not of Australian origin and have been frozen attract a much lower price.
- There are not many Australian species available in the $15 to $25/kg range.

However, in specialist seafood retail outlets, whole, fresh fish are on offer for prices of $5 to $12/kg. Many underutilised species are sold in this manner in low volumes with sporadic/intermittent availability. A small sample of whole fish on sale at the Sydney Fish Market retail outlets revealed the following offerings:

- Red Fish $12/kg
- Latchet $8/kg
- Mullet $8/kg
- Ocean Jacket $5/kg
- Milkfish $10.50/kg

While these prices look attractive, the fillet yield is less than 50%, so the cost per fillet to the consumer is in the $15 to $25 range. And the customer or retailer has to do the cleaning and filleting.

Opinions differ when retailers and wholesalers are questioned about the elasticity of demand between the above four price categories. Some people are of the view that increased marketing of fish in the $15 to $25 category will cannibalize sales from the higher priced categories. Conversely, some buyers from food service companies suggested that there is a latent market for white fish fillets of Australian origin at the $15 to $20/kg price point. As can be seen from the margin analysis below, achieving this outcome profitably is the challenge.

Community Interest and Consumer Awareness

Timing plays a big part in successful market development and it may be that now is the time to take a chance on expanding the market for underutilised species, because public interest appears to be

on the rise. A web search for underutilised seafood species will produce a myriad of articles about restaurants and chefs that are turning to these fish as a cost saving, environmentally sustainable point of difference. Below a number of initiatives from throughout Australia that are aiming to improve consumer acceptability, promote the use of underutilised species.

One high profile example in Sydney is The Fish butchery – "Sustainably caught, underutilised species, expertly prepared for you to cook at home" The company endeavors to use every part of the fish in a range of novel retail food products. See Figure1 and https://fishbutchery.com.au/

Figure 1. The Fish Butchery, Sydney

Carmen's Market in Darwin is another example of an innovative retailer selling underutilised species. The market sells fresh, whole small pelagic species and processing offcuts such as fish wings (figure 2). In conjunction with an adjacent restaurant, underutilised species are offered as in house and take away meals.

Figure 2. Carmen's Market in Darwin

In South Australia a Community Supported Fishery called *Fairfish* has commenced that encourages customers to buy underutilised and seasonally available species direct from fishers on a regular basis.

FAIR FISH

Figure 3. The Fair Fish logo

The idea is that buyers regularly select from product combinations on offer that include one popular species and one secondary species to try something different. Quality, freshness and provenance are key elements of the business strategy. Supporting information and recipes are also provided. The fish still need to be processed and distributed and costs are contained by use of a cooperative structure. More details can be found at https://fairfishsa.com.au

In Western Australia there are 21 small fisheries, mostly fished by small, family owned companies that catch a wide range of species including key, secondary and byproduct (underutilised) species.. The Western Australia Fishing Industry Council (WAFIC) in conjunction with the Southern Seafood Producers (WA) Association and have recently embarked on a market development program for underutilised species. The program refers to “lesser known” species and emphasizes “seasonality”, “heritage” and “local” (figure 4).

Figure 4. WAFIC seafood marketing poster

The marketing program involves point of sale material for retailers, cooperation with regional development councils to include underutilised species in tourist heritage trails, and provision of samples of fish to chefs and cooking schools to encourage them to experiment with them. . The poster in Figure 4 is available from http://www.wafic.org.au/wp-content/uploads/2016/12/A2-WAFIC-EDUCATION-POSTER_r15.pdf

A similar community initiative is found in Darwin with the “Support NT Caught” promotion (figure 5.) This is driven by an industry desire to see introduction of country of origin labelling of seafood in all consumer outlets, including restaurants. There is a firm belief that the demand for local underutilised species is depressed by the capacity of retailers and food service operators to import cheap seafood and not declare its source of origin to restaurant patrons.

Figure 5. Support NT Caught Poster

The Lantern Project was founded in 2013 by Cherie Hugo, a dietitian and PhD scholar with a focus on aged care (figure 6). The project has a wide range of collaborators working collectively to improve the quality, nutritional value and enjoyment of food in aged care centres. Seafood has been identified as very desirable component of meals for the elderly and the challenge is to find fresh, Australian white fillets at a reasonable price. Some seafood wholesalers are participating in this initiative using underutilised species. See www.thelanternproject.com.au.

THE LANTERN PROJECT
Good Food. Better Health. Aged Care.

Figure 6. The Lantern Project

Value added, quality products

Poor quality has become almost synonymous with underutilisation in the seafood world. But from there opportunities arise. For example, people buying fresh fish fillets from supermarkets and specialist seafood retailers shy away from species they do not recognize, but presenting them in a quality format makes them more appealing, for example in the Fish Butchery (see above).

Some species are underutilised primarily because their flesh quality deteriorates rapidly if they are not chilled immediately after catching. Examples include Australian Salmon (*Arripis* spp.), mullet, mackerel, and Australian Sardines. Paradoxically, when properly cared for, these fish can provide very attractive, nutritious options for consumers. The success story behind the South Australian Coorong Fishery becoming Marine Stewardship Council (MSC) accredited and its marketing of Coorong Yellow Eye Mullet (*Aldrichetta forsteri*) is a good example of how consumer acceptance can

be improved by telling the story of the product and maintaining quality (figure 7). Details can also be found at: https://www.coorongwildseafood.com.au/

Figure 7. Yellow Eye Mullet from the Coorong, South Australian

In the same manner, Pipis (*Donax deltoides*) produced in South Australia have been transformed from a low value bait product to a high value gourmet export product by attaining MSC accreditation, developing attractive packaging and attending to product quality (Robinson 2014). All of these actions have seemingly resulted in a shift in consumer perception and demand for this species.

There are similar success stories from the last decade relating to octopus (*Octopus* spp) and Black Mussels (*Mytilus galloprovincialis*).

In the cases above, innovative seafood producers have been able to elicit a change in consumer perception regarding individual underutilised species. However, there are also examples whereby markets have been expanded for underutilised species through development of new seafood and value-added products. The major project on underutilised species at Curtin University assisted the Western Australian fishing industry to developed a range of alternative products (Howieson 2017), some of which are described below.

There is a small consumer group that prefers to buy fresh seafood fillets in sealed plastic trays, the same as red meat and chicken. The important feature of that offering is to have a fresh, white fillet clearly visible in the pack. According to retailers, the species of origin is then less important to the consumer, and by using underutilised species a lower unit price is possible. This has been successfully achieved with Blue Spotted Emperor (*Lethrinus punctulatus*) in Western Australia.

After many years of supplying Western Australia with innovative Australian Sardine products using locally caught fish, the Mendolia Seafood company has recently established a new canning facility near Fremantle. This $5million, export approved facility, is producing high quality canned products using Australian Salmon, Australian Sardines and tuna, see figure 8. A key element of the business is to secure the necessary fish in pristine condition.

Figure 8. Examples of Mendolia Seafoods products

Dried and smoked seafood is very popular in some countries overseas, but less popular in Australia. At present dried seafood is being marketed in Australia as treats for pets. However, there may be opportunities to reposition these products so that they are appealing to the pet owners. Fish jerky is an example (figure 9). The advantage of these products is that the fish species in the product is not of primary concern to the consumers, creating an opportunity for underutilised species.

Figure 9. Example of an American fish jerky product.

Negative demand factors

Unreliable supply

This is a major constraint to the expanded use of underutilised species. Discussions with wholesalers often became quite animated on this issue. It seems every wholesaler has a story to tell about coming to agreement with fishers to create a market for a certain species, only to have the fishers abandon the arrangement in the face of any difficulties or emergence of a new opportunity to catch higher value products. This response from fishers is understandable because the prices paid for underutilised species are so low. The wholesalers could solve the problem by paying more for the fish, but they are also constrained (see below) and they may also need to put money on the table to develop the product.

As with many supply chains in primary industry, the processors usually wish to pay a set price for a set period, so they can create a market and supply it at a known price and margin. This works with

fishers until the market price of the fish exceeds the set price paid by the wholesaler. Of course it is also not unusual for wholesalers to refuse to buy the product if it is not selling. Stories such as this abound in the industry. In this environment, competitive advantage is achieved primarily though strong personal relationships, or by gaining control of the fishing operation by buying/leasing permits and vertical integration of businesses.

Poor quality

With the exception of prawn trawlers that freezer their catch at sea, most fishing vessels in Australia do not have onboard freezers. The catch is kept cool with ice or refrigerated seawater. Consequently, on a long trip, fish caught on the first day are poorer quality than fish caught on the last day. Greater attention is naturally paid to maintaining key species at low temperatures. This means that underutilised species often arrive at port in a poor condition, which perpetuates their status as low value commodities.

The common perception and reality that underutilised species are of low quality is a barrier that must be broken down at each level of the supply chain if these species are to be exploited further. A demonstration of the scale of the change required can be found in the quality specifications used by the wholesale foodservice distributor Bidfood to assess the quality of its incoming food supplies. This specification runs for eight pages for processed product.

Lack of retail customer knowledge

It is well established that Australian consumers, particularly those born here, will only buy fish that they recognize and know how to cook. This extends to recreational fishers who primarily target these icon species. Species such as whiting, snapper, gummy shark, barramundi and flathead are household names that consumers trust. This trust can be very resilient. In a Seafood CRC consumer tasting study, the members of the public involved would not believe the fish they were offered was Barramundi because it tasted bad (Danenberg 2012).

The popularity of these icon species can be further boosted by regional fervor. For example, Australian Herring known is known to all anglers as Tommy Ruff in SA, but is largely unknown elsewhere. Red Emperor is a highly valued fish in WA but little known in other States.

The fact is that there are many fish species that are equally as tasty as the icon species, but consumers see past them, or deliberately avoid them in the belief they are poor quality. Research conducted by the Seafood CRC found that this attitude could be turned around in some consumers by comparing the taste of the unknown species to a recognized species. In one experiment, a significant proportion of consumers accepted Latchet fillets when provided with the tag line “tastes like flathead but half the price” (Danenberg 2012).

It is likely that a marketing campaign could change consumer perceptions about the taste of underutilised species, but there is unlikely in the absence of a coordinated, national, seafood marketing initiative. Therefore, the initiatives that are occurring locally are worthy of support. This should only be conducted in conjunction with efforts that will improve the quality of the products on offer.

Lack of wholesale customer knowledge

Most people in the seafood trade have a good idea of the range of species available at markets and from major fishing fleets. This is the knowledge that is common to the industry - the “known” information. However, not so many people are fully aware of the variety and volume of underutilised species - the “unknown” information. Vertically integrated operators have information

about availability, seasonality, tonnages, flavor, processing features, and quality of fish that are rarely brought to market. But this information is not distributed in a systematic way.

This explains why wholesalers and exporters consulted during this project were keen to obtain a copy of the tonnage and prices paid for discarded fish in the GABTF, as reported by Koopman (2017). Similar information is available in the report by Howieson (2017) and Kennelly (2017).

As more information is collected through bycatch surveys in future, it will be beneficial to make the results available to the seafood trade, as well as using it to assist fisheries management.

Positive supply factors

Availability

A feature of most underutilised species is that they are available to be harvested in large volumes. Volume of supply is not a limitation. For example, in small pelagic fisheries less than 20% of the total allowable catch has been harvested in recent years (AFMA 2017).

Minimal regulation by fishery managers

By virtue of their underutilised status, these species are generally available in abundance and can be caught by existing fishers at will. New entrants to the fishery would need to buy in. Most trawl fisheries are multispecies and are regulated as such, with landed catches of each species being recorded. If the catch of a species dramatically increases, regulators may increase the level of monitoring and begin a process to set limits.

Where key commercial species are under pressure and stocks are declining, regulators will welcome redirection of effort to other species. For example, this is being encouraged in the South Australian Marine Scale Fishery (Fowler, 2017).

Negative supply factors

Price paid to fishers

The principles of supply and demand apply directly to underutilised species, with poor market demand resulting in low prices paid to fishers.

The report by Koopman et al (2017) on the GABTF is one of the few available that explain payment to fishers in detail. The average cost of fishing was found to be $0.94 /kg of fish landed. Beach prices paid to fishers for the two key commercial species that make up 57% of the landed catch averaged $5.33/kg for Bight Redfish and $4.73/kg for Deepwater Flathead (*Platycephalus conatus*). Prices paid for the two underutilised species that have the most commercial potential and make up 41% of the discards were $1.86/kg for Ocean Jacket (*Nelusetta ayraudi*) and $1.46/kg for Latchet.

By direct contrast, higher prices are paid to fishers in the South Australian MSF, which is a smaller volume, line and net fishery, with fewer underutilised species. The trends are the same however. The beach price for King George Whiting in 2015-16 ranged from $19.08/kg to $15.56/kg, whereas the range for Australian Salmon was $2.70/kg to $1.68/kg (Econsearch 2017)

It is apparent from these prices that a fishing vessel with spare hold capacity on the last days of a voyage would be likely to retain underutilised species because the marginal cost of keeping the fish is minimal and income received would add to profit for the trip. But no vessel would deliberately target these species.

Processing costs and difficulties

It is tempting to assume that all underutilised fish presently returned to the sea could be diverted into the retail or domestic market and sold to consumers at low prices, thereby providing cheap, high quality protein. However, while the price paid to fishers for many fish species is very low, the cost of processing and distribution of fresh fish in Australia results in a relatively expensive final product. This is explained in the margin analysis below.

Table 3. Financial margin analysis for a underutilised species fresh fillet supply chain.

Item	Amount ($/kg)	Cumulative Amount ($/kg)	Amount ($/kg)	Cumulative Amount ($/kg)
Paid to fisher, whole fish	1.50		2.50	
40% fillet yield		3.75		6.25
Processing cost	6.00	9.75	6.00	12.25
Wholesale margin (30%)	2.95	11.70	3.70	15.95
Retail Margin (40%)	4.70	16.40	6.40	22.35
Retail price		**16.40**		**22.35**

There are many variables that can impact on this generic analysis. For example, the fillet yield percentage varies with fish species. Processing costs vary with species according to the degree of difficulty and whether automation is available. Costs for special packaging, freezing, storage, and transport would be additional.

There are several ways in which the final retail cost can be reduced. One is through vertically integrated companies that own fishing, processing and wholesaling capacity; an arrangement which is most likely essential if the product is to be sold fresh. Freezing seafood onboard is not an option for smaller, inshore fishers, but introduction of a factory or "mother" ship with onboard processing and freezing facilities can be profitable. Alternatively, frozen whole fish can be exported to Thailand or Vietnam were it can be processed for a fraction of the above costs then reimported to Australia as frozen fillets. Automation can also reduce costs, but is only available for species that are common throughout the world, such as herring, whiting, salmon, and sardines.

On board hold storage space

Availability of hold space on fishing vessels is an important determinant of whether underutilised species are retained or discarded at sea. Hold space varies according to vessel size and duration of fishing trips. Efficiency of hold storage varies with cooling capacity. At one extreme, vessels fishing in coastal waters close to port might only fish for 2 to 3 days before returning to port. Holds on these vessels are small and cooling is achieved by mixing ice with the fish in tubs. Consequently, space is at a premium and reserved for key commercial species that are transported on ice to market or processors as soon as possible. At the other end of the spectrum are larger vessels with on-board freezer capacity. These vessels can stay at sea for weeks. Either way, underutilised species will only be retained if they are caught towards the end of the fishing trip and hold space is available. Modification of vessel storage capacity involves major capital expenditure and is not feasible in most instances.

Fishing Regulations

In some cases, the regulations drive species into the underutilised category. This occurs in the Northern Territory pelagic fishery which contains a wide range of species. Due to a decision to limit the commercial harvest of one species, Spotted Mackerel (*Scomberomorus munroi*) in favor of

recreational fishers, catch limits have been placed on the whole fishery. This has allegedly resulted in the importation of 300t per annum of small pelagic fish for use as bait by commercial and recreational fishers.

Under-catching of entitlements

A special case in underutilisation is the failure of fishers to harvest all the fish they are entitled to under quota and Total Allowable Catch (TAC) permit arrangements. This situation generally occurs in multi species fisheries where the dynamics of one species can impact on all the others. For example, an abundance of one species might mean there is insufficient time or hold space to catch the full entitlement of other species.

This subject is being studied in detail in a current FRDC project (2016-146) focused on the South and Eastern Scalefish and Shark Fishery (SESSF) (Knuckie 2018). The reasons for the under-catch are a complex mixture of economic, social and fishery management issues. The report is yet to be finalised (at the time of writing) and when it is, the recommendations should be read in conjunction with this report.

The Export Market

The value of Australian edible seafood exports in 2014-15 was $1,293 million (Savage 2016). Most of this was high value product such as lobster, abalone, tuna, salmon, etc. A relatively smaller volume of 5,752t “other” fish, valued at $42million was exported, of which underutilised species make up an unknown proportion.

Some exporters look to export large volumes of very cheap fish. Fish that can be purchased from vessels at $1/kg or less are frozen whole and stored in freezers until a container load has accumulated. This fish is generally destined for Asian markets.

Other exporters, particularly those that operate fishing fleets, actively seek out markets in Asia for Australian species that suit a range of cultural and economic opportunities. For example, Australian fish that look like Asian species can be sold in times of shortage in Asia. These fish can be sold whole or processed in Australia, then frozen and airfreighted.

The Import Market

In 2014 -15 Australia imported edible fish (excluding crustaceans) to the value$1,055 million (Savage 2016). As significant proportion of these imports were canned, smoked, or battered and bread crumbed in frozen, retail-ready packages. However, frozen fish fillets accounted for 30 % of the value of these imports ($320million). At 55,000t, these imports are approximately the same volume of underutilised species in Australia. Some of this product enters the retail sector at the lower price category, but much of it is used in the food service sector. It is some of the products in this category that might be able to be substituted with local underutilised species. The competition is fierce however. Most of this product comes from countries where the cost of production is low. In some cases, such as Basa (*Pangasius bocourti*) from Vietnam, which can retail in Australia for $7.00/kg, there may also be some degree of government subsidy.

Nonetheless, the quality of processing and packaging is high for most of these products and the market is supplied by well established companies trading in large volumes. It is a far easier proposition for food service companies to place an order from these established supply chains, compared to the variable supply and poor quality of Australian underutilised species.

Fish meal, oil, pet food, fertilizer and fine chemicals

Seafood processing waste is used in Australia to produce pet food, fertilizer, fish meal and fish oil. These end-uses can also be applied to underutilised species that have been caught, are dead, and would otherwise be returned to the sea. The Australian industry is constrained by the low volumes of available material and long distances between source and processor. Onboard processing of underutilised species into silage for use as fertilizer has been proposed for the GABTF (Koopman 2017) but has not been taken up, in part because of the cost of the modifications required to the fishing vessels.

In some counties seafood waste and underutilised species are used to extract fine chemicals. This opportunity in Australia is limited by small volumes of available material, and the need to refrigerate and store the waste until collection. More importantly, there are few if any fine chemical companies active in this area in Australia. The cost of bringing these products to market can be very high and can only be done with regard to a global market. Consequently, any research on this topic should begin with a market analysis conducted by experts in the field. If FRDC is to explore this area further it would be essential to engage the services of a person, likely from overseas, experienced in commercial fine chemical extraction from seafood.

In the context of this report, another concern is that while these activities may minimize wastage, they are unlikely to provide significant extra income for fishers.

The EU Landing Obligation

The reform of the European Common Fisheries Policy (CFP) of 2013 aims at gradually eliminating the practice of discarding through the introduction of the Landing Obligation. The Landing Obligation requires all catches of regulated commercial species to be landed and counted against quota. Undersized fish cannot be marketed for direct human consumption, but must be diverted to other uses. The Landing Obligation is being phased in from 2015 to 2019, using plans prepared for each fishery.

This radical change in fisheries management aims to improve fishing behavior.

The politics and complex community – industry interactions behind the introduction of this legislation are not considered in detail here as they are not applicable to Australia. However, alongside the implementation of the Landing Obligation the European Commission established and major R&D program to help industry adapt to the new regulatory environment. Called *Strategies for the gradual elimination of discards in European fisheries*, or *DiscardLess*, the program began in March 2017 and runs for four years, with a budget of 5.5million Euros (figure 10).

Figure 10. The DiscardLess logo

Information provided on the website (www.discardless.eu) about the program is as follows:

- *DiscardLess* helps provide the knowledge, tools and technologies as well as the involvement of the stakeholders to achieve the gradual elimination of discarding. These will be integrated into Discard Mitigation Strategies (DMS) proposing cost-effective solutions at all stages of the seafood supply chain.
- The first focus is on preventing the unwanted catches from ever being caught.
- The second focus is on making best use of the unavoidable unwanted catch.
- *DiscardLess* evaluates the impacts of discarding on the marine environment, on the economy, and across the wider society. The impacts before, during and after the implementation of the landing obligation, will be evaluated, allowing comparison between intentions and outcomes.
- Research is underway on how to adapt fishing vessels to store discards and bring them to land, and the challenges that this brings in terms of monitoring, control and surveillance. 3D Drawings of Fishing Vessels are provided that simulate how fishing vessels could be designed and equipped in order to cope with discards onboard, based on existing technologies. A cost-benefit calculator is provided that estimates the costs or renovating the vessels and potential payback.
- Experiences from Iceland and Norway, where discard bans have been in place for some time, are explained.
- Developments in control and monitoring, which is proving to be difficult, are being investigated.
- Information is provided on the potential amount and distribution of discards - where they are brought to land, which species, size and quantities.
- Value adding initiatives are explored including use of fish waste for fine chemicals, collagen, oils, fish proteins and enzymes. See figure 11.

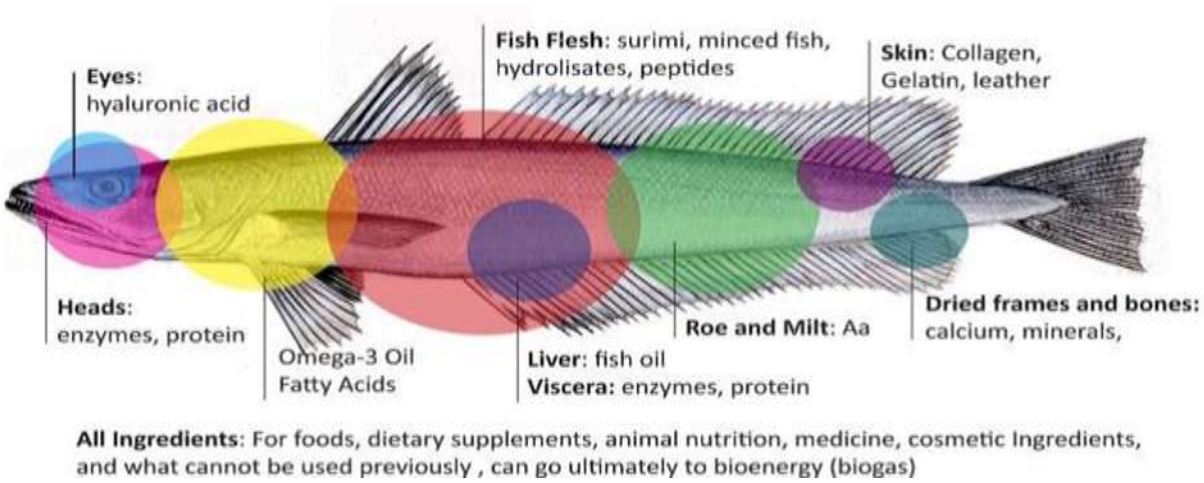

Figure 11. Diagram of value adding opportunities from the *DiscardLess* website.

The economic drivers in the EU are very different to those in Australia, so many of the concepts put forward in *DiscardLess* may not be practical under Australian conditions. In particular, the volumes of underutilised species available in single ports can be 50,000 t or more per annum, more than ten times the volume available in most Australian ports. This scale improves the economic feasibility of

initiatives such as pharmaceutical and nutraceutical value adding. However, *DiscardLess* is a significant body of work that should be “mined” for any opportunities. Australian fisheries consultant Steve Kennelly from IC Independent Consulting serves on one of the advisory committees and may be in a position to help build an alliance between key players in the program and FRDC.

DISCUSSION AND CONCLUSIONS

Fish that are caught and discarded, or left unharvested even though they can be landed legally, are underutilised because there is no market demand for them. Underutilisation occurs in all wild catch fisheries across the globe as unwanted and unavoidable catches. In Australia, an estimated 50,000t of fish, comprising 100 or more species, is underutilised each year.

This study investigated the factors that influence supply and demand of underutilised species to determine if there were opportunities for the Fisheries Research and Development Corporation (FRDC) to facilitate improved use of this resource. The project was conducted in two parts. The first part involved an evaluation of past FRDC projects, described in Part One of this project. The second part, described herein, concentrated on the supply chain.

The underutilised category is not static. Much work has been done in Australia to reduce the volume of discarded fish, for example by fitting exclusion devices to trawl nets, that in some cases have reduced bycatch by half.

Also, fish move out of the category as markets are discovered for them. Over past decades, innovative fishers, often with financial support from the FRDC, have established species that were previously ignored as high value commodities. For example, octopus, calamari, bugs, Pipis, Native Oysters (*Ostrea angasi*), Blues Spotted Emperor, Orange Roughy (*Hoplostethus atlanticus*), and Patagonian Toothfish (*Dissostichus eleginoides*).

It would be of benefit to the community, as a source of protein, and to fishers as a source of income, if more use could be made of underutilised species.

Continuing investment by FRDC has supported many projects that aimed to achieve this goal. Unfortunately, the evaluation of these projects conducted in the first part of this study found that only a small proportion of those projects achieved commercial success and the volumes of fish involved were small, so that the impact on the national tonnage of underutilised species has been minimal.

When projects did achieve success, they were usually led by commercial operators. As stated in the conclusion of the Part One:

> *….The attempted exploitation of an underutilised species in the domestic or export market is a business decision, likely to be based on low profit margins, that must be made by a commercial operator using their own data and supply chain networks.*

This project has identified some entrepreneurial individuals and companies that invested their own funds to develop business opportunities using underutilised species. These companies are usually vertically integrated seafood businesses that own fishing, processing and distribution resources, thus ensuring consistent supply of fish and improved profit margins. In some cases, new investment through foreign ownership has facilitated the opportunity.

Therefore, it could be argued that market forces will gradually reduce the volume of underutilised species. If this is correct and there is no market failure, it would be difficult to justify FRDC contributing funds to projects involving underutilised species.

But the fact remains that each year in Australia around 50,000t of available fish will not be put to good use. The counterfactual argument is that the market is reacting too slowly and as a result, opportunities are being missed.

There are certainly many aspects of the seafood supply chain in Australia that prevent greater uptake of underutilised species. The findings of this report point to the following problems:

- The low prices paid to fishers for underutilised species (less than $2/kg) means they generally make minimal, if any profit by harvesting them.
- The low prices paid to fishers for underutilised species means they may have no compunction about breaking an agreement to supply fish to a wholesaler if a better opportunity arises.
- Limited hold space on fishing vessels means priority is given to high value species.
- Seafood processors will not invest in creating demand for a product that fishers will not supply reliably.
- Some exporters and retailers are not aware of the diversity of available species, as well as their palatability, seasonality, processing characteristics and price points.
- Small fishing companies and associations that are willing to harvest underutilised species and help create demand have limited knowledge and experience in negotiating supply arrangements with wholesalers.
- With cheap, frozen fish fillets available to be imported from Asia, there is limited motivation for wholesalers to take any risk in attempting to create a market for local underutilised species.
- Most Australians will not buy fish that they do not recognize and the absence of any industry market development activities precludes any consumer education on the subject.
- The small volumes of underutilised species available on a day by day basis, and the wide diversity of species means that most of the options for automation of processing are not cost effective.
- The export of Australian underutilised species is made difficult by the low prices received, low volumes available relative to global volumes and diversity of species.
- Fishing regulations will occasionally prohibit harvesting of some species as a secondary consequence of protecting other species

In addition to the above points, the muted use of underutilised species in Australia may partly be due to culture and attitudes. With a relatively small population that is accustomed to high quality offerings of a limited number of well-known fish species, reliably supplied by generally profitable fishing fleets; the drivers to present new species to the market are limited.

Many of these problems could be mitigated if there was greater consumer demand for seafood.

There is some demand for some lesser known, smaller fish species due to market demand in Asia, growth in domestic ethnic populations, interest from high profile chefs and renewed community interest in waste reduction and food security. Examples include Ocean Jackets, Australian Sardines, Australian Salmon, mullet, hagfish.

There is a market for mid-price point white fish fillets, particularly from institutional caterers. Some companies and fishing organisations are taking initiatives to meet and build this demand. Generally, the fish targeted in these initiatives are sold at retail prices less than the better known species (approx. $15/kg to $20/kg for fillets). This makes the business marginal.

To date these initiatives have not created sufficient demand to encourage food service suppliers, wholesalers and supermarkets to drive major change in the supply chain. It is therefore up to the fishers, as the primary producers and first in the supply chain, to attempt to lift demand for underutilised species. There is an argument for FRDC to use R&D levies collected from fishers to assist in this task.

The fundamental objective of any such project must be to transform any given underutilised species to a food item for which there is a sustained market demand at a price point that provides a reasonable margin to all of the businesses involved.

Success in achieving this should result in the product establishing a new, high value niche, and becoming part of the regular seafood offering expected by consumers in a retail, restaurant or food service setting.

The Part One for this project made recommendations about how these projects could be structured in future and provided a check list to assist in determining whether projects were likely to achieve the desired commercial outcomes. These recommendations are:

- Projects should be initiated and led by a commercial operator (not an industry association) that signs the Funding Agreement with FRDC and is accountable for the outcomes.
- Projects should be preceded by a financial analysis conducted by the commercial operator.
- FRDC funds should only be used for research to fill knowledge gaps identified by the financial analysis.
- If the research to fill the gaps is conducted by a public sector agency it should be subcontracted by the commercial operator, rather than FRDC.
- Applications for such projects should only be approved when more than eighty per cent of the 34 success criteria in the checklist developed as Part One of the project are met (refer to Table 4 in Part One of the report).

These recommendations are applicable when an entrepreneurial commercial operator is already committed to the project. However, these entrepreneurs are rare. FRDC might therefore have a role in building linkages between each stage of the supply chain and attracting new, entrepreneurial entrants into the Australian seafood sector.

Constructive dialogue about new seafood opportunities between retailers, food service providers, wholesalers, processors and fishers is difficult to establish. Forums through which these groups can discuss innovation are rare and there are few industry associations representing post-harvest companies with which fisher associations can engage in constructive dialogue on innovation and commercial matters. Also, being funded through levies paid by fishers, rather than the post-harvest sector, FRDC does not employ program managers whose responsibility and accountability is to the post-harvest sector. As a consequence, there is little capacity to build networks based on trust and mutual understanding between fishers, FRDC and the post-harvest sector. This prevents the sharing of commercial knowledge to facilitate supply chain improvement.

Sharing of this knowledge is critical to getting a project started and to its ultimate success. This study found many fishers, processors and wholesalers that were vaguely aware of business opportunities involving underutilised species, but did not act on them. This was because they did not have the necessary personal contacts, time, knowledge, project management experience and understanding

of government funding opportunities. Their desire to maintain confidentiality of their ideas was also an important consideration.

This problem has been recognized by FRDC and attempts have been made to solve it by providing the services of scientists and consultants to help design projects by building relationships with potential participants, in full confidentiality. Three people engaged in this task contributed their insights to this study. All confirmed that it is useful but is a difficult, slow process in which success is elusive, for many of the reasons stated above.

A solution to this situation might be for FRDC to employ a full time program manager with expertise in food service and retailing. The primary role of this manager would be to build much better lines of communication with the food service/retail sector, and to educate fishing businesses on how to work with them. The full time role would be important to enable the person to educate FRDC staff and build trust with industry.

To test this proposition, it is recommended that:

1. FRDC establishes a three-year trial appointment of a project manager who can build better lines of communication with the food service/retail sector. It would be essential for the person to have wide experience and credibility in the sector, to enable them to overcome barriers with the seafood industry. The manager could also assist in identification of entrepreneurs, building networks, project design, cost sharing between companies, technical issues and funding applications.

Some of the people behind the successful initiatives mentioned in this report might be willing to contribute their experience to the greater good. The new manager could work with these people to identify further opportunities. It is recommended that:

2. An informal group of underutilised species innovators is established to work with FRDC to develop ideas for overcoming supply chain blockages and identify new opportunities.

There are situations where fishery regulations drive a species into the underutilised category, either by preventing their catch or requiring fish to be discarded at sea. This is generally the result of trade-offs that must be made between ecological, recreational and commercial interests. Such issues are localised and need to be solved at a local level.

The Australian fishing industry does not need to tackle this problem alone. The *DiscardLess* R&D program, established by the European Commission to assist implementation of the new Landing Obligation regulations, may be a valuable source of innovative ideas that could be adopted by Australian companies. The economic drivers in the EU are very different to those in Australia, so many of the concepts put forward in *DiscardLess* may not be practical. However, it is a significant body of work that should be "mined" for any opportunities. Similar programs are likely to exist in other countries, for example www.seafoodinnovations.co.nz.

It is therefore recommended that:

3. FRDC establishes formal and personal links with international programs such as the European Union *DiscardLess* research program, with a view to transferring to the Australian industry any novel concepts for avoiding underutilised species and effective use of those species that are caught.

Seafood processing waste is used in Australia to produce pet food, fertilizer, fish meal and fish oil. These end-uses can also be applied to underutilised species that have been caught, are dead, and

would otherwise be returned to the sea. This industry is constrained by the low volumes of available material and long distances between source and processor. In some counties seafood waste and underutilised species are used to extract fine chemicals. This opportunity in Australia is also limited by small volumes of available material, the need to refrigerate and store the waste until collection and the absence of any fine chemical companies active in the area. This activity is not a primary subject of this report. However, if FRDC is to explore it further it would be advisable to engage the services of a person, likely from overseas, experienced in commercial fine chemical extraction from seafood. In the context of this report, another concern is that while these activities may minimize wastage, they are unlikely to provide significant extra income for fishers. A recommendation for FRDC to consider is:

4. Any investigation of the use of underutilised species for fine chemical extraction should be preceded by an investigation conducted by a person with commercial experience in the process.

Given that the problem of underutilised species is largely one of limited market demand, some activity in the area of market development is warranted. Simply increasing buyers' awareness of the range, tonnage and seasonality of currently underutilised species available from each fishery would be of value. Currently this information is not made public, which puts potential new entrants and investors at a disadvantage, particularly export customers. Without this knowledge it is difficult to begin a conversation about how to explore opportunities. It is recommended that:

5. FRDC produces a tabulated summary of tonnage and seasonality of underutilised species available in each Australian fishery with a description of the eating quality and processing attributes of each species. This should be made available to the food service industry and to seafood importers and exporters.

Market demand can also be improved by promotion. Individual fisheries, associations and chefs are conducting limited promotions and wherever possible these should be supported and expanded. This is a problematic area for FRDC, given its "RD&E only" constitution, but there are areas of consumer education and public awareness where FRDC is free to operate. FRDC could also attempt to coordinate these activities to achieve greater impact. In the longer term it is anticipated that FRDC may be able to collect voluntary marketing contributions from industry, thereby enabling more significant market development initiatives. It is recommended that:

6. Within its legislated constraints, FRDC should seek opportunities to assist industry conduct market development and public awareness activity in support of expanded use of underutilised species.

The above recommendations fit with the conventional mindset of FRDC and its stakeholders. If implemented, they are likely to assist some entrepreneurial companies develop new markets for underutilised species. The cost of implementing the recommendations is not significant and much of the funds needed to drive new projects should come from participating companies, leaving FRDC to fill a coordination and support role.

However, major improvement in the way fishers and the food industry see underutilised species is likely to need more transformational, disruptive change. Recently a new opportunity to attempt this has been identified by FRDC.

A New Way Forward?

The new approach to addressing underutilisation in Australia's wild catch sector involves a completely different mindset to how research and development is planned and executed, as described by the Food Futures Company. This company is working with FRDC to conduct some case studies in which Design Thinking is used to bring about change in complex systems. In these systems it is essential that commitment about future directions is achieved by bringing together and aligning the interests of different stakeholders who will be impacted by the project and/or who have the ability to themselves impact project outcomes. If the case study proceeds, FRDC would take on responsibility as the innovation system designer and examine underutilisation from a whole system perspective. The objective would be to develop an initiative that would be seen as an investment proposition by interested businesses and communities.

This approach may be particularly relevant for industry challenges such as underutilised species, where the ultimate opportunity is apparent to all but dysfunctionality of the current supply chain prevents realization of the opportunity. Therefore, it is recommended that:

7. FRDC works with the Food Futures Company to conduct a case study on underutilised species using Design Thinking to achieve supply chain innovations that may ultimately lead to transformative improvements of benefit to key participants.

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APPENDIX 1: CONSULTATION

The author wishes to sincerely thank the following people for their assistance with this project.

Name	Organisation
Abbott, Toby	Kailis Bros Group
Bicknell, Nathan	Marine Fishers Association, SA
Boulter, Mark	Safe, Sustainable Seafood Consultancy
Catalano, Paul	Catalano Seafood, WA
Ciconte, Anthony	Northern Territory Seafood Council
Clark, Beau	South Australian processor
Colquhoun, Ewan	Ridge Partners
Cosentino, Tom	Fair Fish SA
Day, George	Australian Fisheries Management Authority
Diacos, Stefan	Raptis Seafood
Drago, Julie	Mendolia Seafoods Pty Ltd
Fish, Rob	Northern Territory Seafood Council
Fletcher, Rick	Department of Primary Industries and Regional Development, WA
Fowler, Anthony	South Australian Research and Development Institute
Frank	Seafood Exporters Australia Pty Ltd
Grant, Norm	Australian Seafood Importers
Harrison, John	Western Australia Fishing Industry Council
Haywood, Dennis	MG Kailis Group
Hogan, Brett	Mareterram Ltd
Holder, Dennis	President, Wild Catch SA
Howieson, Janet	Curtin University
Hugo, Cherie	The Lantern Project
McCaskill-Ball, Carmel	Carmel's Seafood Market, Darwin
Knuckey, Ian	Fishwell Consulting
Lochowicz, Darren	MG Kailis Group
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Passey, Bill	Australia Bay Fisheries
Rayns, Nick	Australian Fisheries Management Authority
Richardson, Terry	Aussea Pty Ltd
Spinella, Biagio	Austop Fisheries
Tavani, Ennio	Mendolia Seafoods Pty Ltd
Wellham, Gary	Bidfood Supply Solutions
Winchester, Katherine	Northern Territory Seafood Council
Ziolkowski, Alex	Seafood Consulting Services Pty Ltd

APPENDIX 2: GREAT AUSTRALIAN BIGHT TRAWL SECTOR DISCARD SPECIES

Catch classification table for Great Australian Bight Trawl Sector species, average annual catches, discards, and prices. From: Koopman et al. 2017

Key species	Average CDR catch GABTS (between 2005-2014) (kg/year)**	Estimated average annual discards for GABTS between 2005-2014 (kg)***	Average price whole fish ($/kg)
Deepwater Flathead	907,586	4,852	$5.33
Bight Redfish	471,141	421	$4.73
Gemfish	**39,729**	**50,275**	**$2.70**
Ocean Jacket	**217,643**	**165,713**	**$1.86**
Orange Roughy	57,140	1,656	$4.65
Gummy Shark	44,867	1,027	$6.59
Yellowspotted Boarfish	68,473	923	$3.55
Blue Grenadier	20,502	712	$2.48
Secondary species			
Ornate Angelshark	77,690	45,502	$1.79
Jackass Morwong	58,092	10,726	$3.28
Australian Tusk	18,283	1,224	$14.67
Latchet	**62,314**	**780,284**	**$1.46**
Gould's Squid	48,441	11,108	$2.08
Blue Morwong	32,094	275	$3.34
Byproduct			
Knifejaw	42,194	20,417	$2.83
Pink Ling	7,131		$5.72
King Dory	6,714	220	$6.18
Barracouta	**119**	**138,554**	**$1.00***
Sawsharks	25,994	17,529	$2.14
Red Gurnard	32,246	14,986	$2.93
Snapper	10,916	197	$7.68
Reef Ocean Perch	364	1,458	$3.27
Skates & Rays (Banjo shark, Skates, Skates & rays, Southern Eagle ray)	**617**	**365,910**	**$1.00***
Silver Trevally	16,604	7,725	$4.27
Bigspine Boarfish	1,161	179	$3.01
Wobbegongs blind nurse carpet & zebra shark	9,398	217	$1.92
Dogfish (dogfishes, Endeavour dogfish, Spurdog)	**3,225**	**199,577**	**$1.00***
Silver Warehou	16,849	121	$1.82
Hapuku	2,216		$8.01
Ribaldo	4,446	1,059	$2.05
Rubyfish (mixed)	13,359		$5.16
Stingarees	**72**	**456,568**	**$1.00***
Boarfishes	4,258		$3.63
Southern Calamari	16,476	1,115	$11.72
Blackspot Boarfish	9,330	10,697	$1.98
Total	2,435,876	2,311,227	

APPENDIX 3: SPECIES GROUPINGS OF DISCARDS IN FOUR STATES

Northern Territory discard estimates (and SE's) for each fishery in the Northern Territory with total estimates for all fisheries and fishing methods. From Kennelly, 2018

Fishery	Retained catch (tonnes)	SE	Discarded catch (tonnes)	SE
Demersal	2453.17	197.26	393.23	35.90
Timor Reef	722.93	35.60	75.39	23.75
Barramundi	718.01	123.15	228.83	148.72
Offshore Net and Line	613.58	158.81	112.73	39.11
Spanish Mackerel	255.23	34.11		
Mud Crab	224.16	50.39	33.40	8.48
Coastal line	111.88	8.36	10.63	10.63
Trepang	51.56	13.11	0.00	0.00
Restricted Bait	31.44	7.03	0.00	0.00
Aquarium Display	10.21	2.16	0.00	0.00
Coastal net	6.53	1.54	0.33	0.33
TOTALS:	**5198.72**	**290.81**	**854.53**	**160.27**
Overall Discard % =			**14.12**	**2.65**

Queensland discard estimates (and SE's) for each fishery and fishing method with total estimates for all fisheries and methods. From Kennelly, 2018.

Fishery	Retained Catch (t)	SE	Total discards (t)	SE	Notes
Coral	88.40	6.39	0.00	0.00	
Crayfish and Rocklobster	153.40	11.93	0.00	0.00	
East Coast Pearl	0.05	0.04	0.00	0.00	1
Marine Aquarium Fish	32.10	2.73	0.00	0.00	2
Trochus	7.40	4.15	0.00	0.00	
Coral Reef Finfish	1388.80	33.05	222.21	222.21	
Deep Water Finfish	3.00	1.48	0.37	0.19	
Gulf of Carpentaria Line	194.80	16.16	18.51	18.51	
Rocky Reef Finfish	142.40	8.81	14.95	5.06	
East Coast Inshore Finfish Fishery	4598.60	84.09	280.51	55.41	
Gulf of Carpentaria Inshore Finfish	1952.60	219.92	99.58	99.58	
Blue Swimmer Crab	361.60	12.27	44.12	44.12	
Mud Crabs	1357.20	50.02	404.45	51.05	
Spanner Crabs	1086.80	66.35	253.96	16.20	4
East Coast Otter Trawl	7482.00	259.20	25064.70	1360.11	5
Gulf of Carpentaria Developmental Fin Fish Trawl	187.60	115.93	119.88	119.88	
River and Inshore Beam Trawl	223.80	25.89	55.95	55.95	
TOTALS	**19,260.55**	**381.35**	**26,579.18**	**1391.02**	
TOTAL DISCARD RATE (%):			**57.98**	**3.03**	

[1]Retained catches have assumed an average weight of 500g per oyster
[2]Retained catches have assumed an average weight of 250g per fish
[3]Combines data for the adult and juvenile components of the fishery
[4]Includes 4 tonnes of non-spanner crab discards
[5]Includes data for the Fin Fish (Stout Whiting) Trawl fishery

Tasmanian discard estimates (and SE's) for each fishery and fishing method with total estimates for all fisheries and fishing methods. From Kennelly, 2018

Fishery	Method	Retained catch (tonnes)	SE	Discarded catch (tonnes)	SE
Abalone	Dive	2139.80	124.50	192.58	192.58
Southern Rock Lobster	Pots	1126.70	52.60	2188.66	174.14
Scallop	Dredge	677.90	185.70	74.57	74.57
Octopus	Pots (unbaited)	79.50	14.30	0.00	0.00
Giant Crab	Pots	29.40	2.80	15.00	15.00
Scalefish	Automatic squid jig	251.00	183.60	0.00	0.00
	Beach seine	243.70	62.20	0.49	0.49
	Purse seine	239.60	198.60	0.00	0.00
	Graball net	105.90	5.80	38.09	38.09
	Hand line	81.00	2.80	11.34	11.34
	Danish seine	70.50	8.70		
	Squid-jig	51.40	3.90	0.00	0.00
	Dip-net	19.30	1.50	0.00	0.00
	Small mesh net	11.00	1.70	7.28	7.28
	Troll	8.80	1.50		
	Fish trap	8.50	0.40	0.17	0.17
	Drop-line	5.20	1.00	0.36	0.36
	Spear	4.20	0.30	0.00	0.00
	Hand collection	2.70	0.80	0.00	0.00
Dive and Shellfish	Hand Collection	42.90	4.60	0.00	0.00
Totals		**5199.00**	**360.76**	**2528.54**	**273.55**
	Overall Discard % =			**32.72**	**3.54**

New South Wales Discard estimates (and SEs) for each fishery and method with total estimates for all fisheries and methods. From Kennelly, 2018

Fishery	Method	Tonnes Retained	SE	Tonnes Discarded	SE
Estuary	Meshing net	2024.02	48.43	293.15	89.68
	Hauling net (general purpose)	948.35	132.90	1051.72	318.93
	Prawn net (set pocket)	157.84	24.84	37.09	17.49
	Crab trap	111.28	11.10	15.83	2.25
	Fish trap (bottom/demersal)	105.24	18.55	14.73	14.73
	Flathead net	91.35	10.31	81.95	26.14
	Prawn net (hauling)	73.75	6.09	18.60	7.30
	Hand gathering	73.60	14.41	9.20	2.10
	Prawn running net	53.01	4.81	7.29	1.14
	Seine net (prawns)	44.52	5.14	21.81	9.45
	Bait net	19.03	4.87	0.00	0.00
	Handline	13.69	1.81	1.92	1.92
	Pilchard, anchovy & bait net - beach based	6.59	1.08	0.00	0.00
	Setline	3.58	0.63	0.47	0.47
	Dip or scoop net (prawns)	0.50		0.00	0.00
	Otter trawl net (prawns)	387.14	36.88	92.83	55.64
Ocean Trawl	Otter trawl net (prawns)	1728.41	98.32	3458.69	941.86
	Otter trawl net (fish)	1253.93	90.15	1058.74	265.99
Ocean Hauling	Hauling net (general purpose)	2382.16	162.68	4.76	4.76
	Purse seine net	1780.64	291.51	0.00	0.00
	Pilchard, anchovy & bait net - beach based	56.87	11.34	0.00	0.00
	Garfish net (hauling) - boat based	34.10	7.59	0.00	0.00
	Garfish net (hauling) - beach based	7.40	3.15	0.30	0.30
Ocean Trap & Line	Fish trap (bottom/demersal)	594.51	37.68	11.30	11.30
	Handline	410.78	29.22	57.51	57.51
	Setline (demersal)	135.75	6.23	20.36	20.36
	Spanner Crabbing	111.00	12.08	34.90	4.54
	Jigging	87.09	9.73	12.19	12.19
	Dropline	72.46	13.67	5.07	5.07
	Setline	52.15	8.50	6.88	6.88
	Poling	45.28	15.57	6.34	6.34
	Trotline (bottom set)	28.06	9.43	4.21	4.21
Abalone	Diving	105.77	9.78	9.52	9.52
Lobster	Trapping	150.38	3.87	126.32	126.32
Others	Pilchard, anchovy, bait net	3.50	1.54	0.00	0.00
	Skin Diving	1.63	0.94	0	0
	TOTALS	13,155	394.4	6,464	1045
	DISCARD PERCENTAGES			**32.95**	**5.33**

APPENDIX 4: UNDERUTILISED SPECIES DATABASE

Fishery	Underutilised species	Harvest challenges/opportunities	Processing Challenges/opportunities	Market challenges /opportunities
South coast estuarine (WA) West Coast beach seine (WA) Ocean hauling (NSW) Small Pelagic (Commonwealth)	Sardines	Inconsistent supply, large volumes can be caught (currently under caught) but would require rapid cooling and boats are small and insufficient land based infrastructure. Larger boats with on board processing facilities to fish quota???	short shelf-life, insufficient freezing/cooling space near regional landing places.	Market perception as "cat food" Low price, high volume product Cape Le Grande launched (frozen chain) (2010/775) Consumer perceptions can be changed/sexy products can be produced (EB report). Freo Octopus marinated local sardine product now marketed. Featured in Seafood festival Esperance (information sheet produced)
South Coast Salmon (WA) Southwest Coast salmon (WA) Ocean Hauling (NSW) Marine Scalefish (SA) Scalefish (Tas)	Australian salmon	Short season, Low value, poor quality due to beach seine handling Under caught	short shelf-life studies have demonstrated fillets and H and G can be frozen with good quality results.	Market perception as "neighbours fish" No retail presence
South Coast beach Seine Fisheries (WA)	White bait		Labour cost to process(very small)	No Market presence
South Coast beach Seine Fisheries (WA)	Blue sardines		Labour cost to process(very small)	No Market presence
South Coast beach Seine Fisheries (WA)	Blue spat		Labour cost to process(very small)	No Market presence
South coast wetline/trap/crustacean fishery (WA) Northern Pilbara prawn trawl (WA) Great Australian Bight (Commonwealth)	Leatherjacket/ocean jacket	Catch information, levels not known: Some Fisheries under review in 2014 Too small to handle Lack of data, difficult to get samples. (GAB)	Very sweet flesh Few scales, high yields on filleting Develop species specific filleting skills, variation in size of product	Markets already identified, processors already engaged. Featured in Seafood festival Esperance (information sheet produced) Consistency of product supply???, unknown in markets

Fishery	Underutilised species	Harvest challenges/opportunities	Processing Challenges/opportunities	Market challenges /opportunities
Scalefish (TAS) Ocean Trap & Line (NSW)				
South Coast wetline/trap/crustacean	Champagne crab	Inconsistent/seasonal catch rates	Spines may cause off flavour	Featured in Seafood festival Esperance (information sheet produced) Plan developed for consultation
West Coast Purse seine	tropical sardinops		Too small to fillet economically	Low/no market perception
West Coast Purse seine	Sardinella	(2000 tonne quota)		
West Coast Purse seine	Scaly mackerel			
Pilbara Finfish Trawl (detailed in Appendix)	Small trawl reef fish	Caught in large quantities but not retained	Too small to economically fillet, difficult to sell as whole fish	Low/no market perception
Pilbara fish trawl Northern Pilbara prawn trawl Ocean Trawl (NSW)	Whiting sand, stout, school-not King George). Stout and red spot whiting	Commercial volumes but need to be moved away from boats (taking up space for more valuable fish) and processed rapidly.		
Northern Pilbara prawn trawl	goatfish (palatability??)	Prawn mesh is smaller therefore finfish/invertebrate bycatch is only small sizes, (check for species targeted by other fisheries (and also look for non-rec fishing targets) In terms of abundance:	Sorting/removing of extra species will slow production down, need to have things easier to grab and sort, many baskets for separation, storing chilled/space.(look at seasonality of prawn catches i.e. target in less busy times, egg early and late in season).	
Northern Pilbara prawn trawl	grinners (lizard fish)			
Northern Pilbara prawn trawl Western Deep Sea Fishery (line/trap is WADoF, trawl is	Flathead (bar tailed more common but mixture) Southern sand flathead			Markets already established

Fishery	Underutilised species	Harvest challenges/opportunities	Processing Challenges/opportunities	Market challenges /opportunities
Commonwealth (Steve Bolton) GAB Scalefish (Tas) Ocean Trawl (NSW) East Coast Inshore Fin Fish (QLD)	Tiger Flathead Tiger Flathead	1650 quota (2012) (GAB)		
Northern Pilbara prawn trawl	flounder (bottom dwellers)	Individual boats/skippers have different approaches to retaining these products , crew may not want to bother Commercial volumes but need to be moved away from boats (taking up space for more valuable fish/prawns) and processed rapidly.	Need for a “mother ship” to remove catch to stop volume worriers If target species suddenly in large volumes then consistency of supply may be a problem	
Northern Pilbara prawn trawl WRL fishery	Octopus	Ditto Poor handling leading to poor quality product	ditto	Poor quality therefore not human consumption market but opportunities exist
Northern Pilbara prawn trawl	cuttlefish prawn killers (stomatopods)	ditto	ditto	
WRL fishery GAB SESSF	Silver Warehou	Under caught by 1500 tonnes based on quota	Flesh turns grey and looks unattractive, also soft Partially thawing cutlets, vacuum seal and re freeze- white appearance and firm texture will be maintained	Previous research projects to add value have proved unsuccessful
Western Deep Sea Fishery (line/trap is WADoF, trawl is Commonwealth GAB	Boarfish	Deep sea fishery, harsh conditions need big boats little information on best practice harvest Little information on species/volumes/seasonality (but expectation is low productivity)	Bones near head, difficult to fillet Not economic to harvest at current prices Bone structure, low filleting yields, waste management	

Fishery	Underutilised species	Harvest challenges/opportunities	Processing Challenges/opportunities	Market challenges /opportunities
		Regulators may lack Confidence in developing sustainable fishery??(cf orange roughy experience)		
Western Deep Sea Fishery	Mirror Dory	Little data		
Western Deep Sea Fishery GAB	Red Bightfish	1556t quota (GAB)		Markets already established.
Western Deep Sea Fishery	Ocean Perch			
Western Deep Sea Fishery GAB	Gem fish	400 t trigger for assessment/management indicating potential for development Classified as overfished on east coast		
Western Deep Sea Fishery	Red Gurner			
Western Deep Sea Fishery	Deepwater bugs			
GAB Scalefish (TAS)	Jackass morwong @			Consistency of product supply?, unknown in market
GAB	Blue morwong			
Ocean Trap & Line (NSW)	Grey morwong			
GAB	Knifejaw			Consistency of product supply???
GAB Southern and Eastern Scalefish (AFMA)	Blue grenadier#@	400 t trigger for assessment/management indicating potential for development Under caught by >2000 tonnes based on quota		Consistency of product supply???
Demersal (NT) Spanish Mackerel (NT) Ocean Trawl (NSW) Ocean Trap & Line (NSW)	Trevally Silver Trevally Silver Trevally	Trap, line, trawl. Bycatch made up 20% trawl in 2012.	Soft flesh	

Fishery	Underutilised species	Harvest challenges/opportunities	Processing Challenges/opportunities	Market challenges /opportunities
Coral Reef Fin Fish (QLD) East Coast Inshore Fin Fish (QLD) E Coast Spanish Mackerel (QLD) Fin Fish Trawl (QLD)				
GAB Ocean Trap & Line (NSW) Deepwater Fin Fish (QLD)	Blue eye trevalla*#@	100 t trigger for assessment/management		
GAB	Ribaldo	100 t trigger for assessment/management		
GAB Deepwater Fin Fish (QLD)	Hapuku#@	100 t trigger for assessment/management		
GAB	Latchet fish			
Barramundi (NT) Gulf of Carpentaria Inshore Fin Fish (QLD)	Blue threadfin			
Barramundi (NT)	Queenfish			
Barramundi (NT) Gulf of Carpentaria Inshore Fin Fish (QLD) East Coast Inshore Fin Fish (QLD)	King threadfin (394 t 2012) Threadfins			
Demersal (NT)	Scads			
Spanish Mackerel (NT)	Wahoo	100kg bycatch, >83% released in 2012		
Spanish Mackerel (NT)	Queenfish			
Timor Reef (NT)	Tropical snapper			
Timor Reef (NT)	Triggerfish			
Timor Reef (NT)	Catfish			
Timor Reef (NT)	Chinaman fish			
Scalefish (TAS)	Bastard trumpeter 9.4t in 12/13	Trolling, graball net, beach seine, purse seine, gillnet, Danish seine,		

Fishery	Underutilised species	Harvest challenges/opportunities	Processing Challenges/opportunities	Market challenges /opportunities
		spear, hand line, drop line, dip net, fish trap		
Scalefish (TAS)	Blue warehou 8.5t in 12/13			
Scalefish (TAS)	Yelloweye mullet 9.2t in 12/13			
Scalefish (TAS)	Pike 8.2t in 12/13			
Scalefish (TAS) East Coast Inshore Fin Fish (QLD)	Southern garfish 51.5t in 12/13	Classified as transitional-depleting in some SA cases.		
Scalefish (TAS)	Striped trumpeter 13t in 12/13			
Scalefish (TAS)	Blue-throated wrasse 49.5t in 12/13			
Scalefish (TAS)	Purple wrasse 12.8t in 12/13			
Ocean Hauling (NSW) East Coast Inshore Fin Fish (QLD)	Sea mullet			
Ocean Hauling (NSW)	Blue mackerel			
Ocean Hauling (NSW)	Yellowtail scad			
Ocean Hauling (NSW) Ocean Trap & Line (NSW)	Yellowtail bream			
Ocean Trawl (NSW)	School prawns			
Ocean Trawl (NSW)	Royal red prawns			
Ocean Trap & Line (NSW)	Bonito			
Coral Reef Fin Fish (QLD)	Nannygai	Hand line. Many bycatch species but comprise less than 10% of the catch.		
Coral Reef Fin Fish (QLD) Finfish Trawl (Qld)	Cods			

Fishery	Underutilised species	Harvest challenges/opportunities	Processing Challenges/opportunities	Market challenges /opportunities
Deepwater Fin Fish (QLD)	Flame snapper			
Deepwater Fin Fish (QLD) Rocky Reef Fin Fish (QLD)	Mahi mahi			
Deepwater Fin Fish (QLD)	Rusty jobfish			
Deepwater Fin Fish (QLD) Rocky Reef Fin Fish (QLD)	Amberjack			
Deepwater Fin Fish (QLD)	Lavender snapper			
Deepwater Fin Fish (QLD)	Pearl perch			
Deepwater Fin Fish (QLD)	Bar cod			
East Coast Inshore Fin Fish (QLD) Gulf of Carpentaria Inshore Fin Fish (QLD)	Grey mackerel			
East Coast Inshore Fin Fish (QLD) East Coast Spanish Mackerel (QLD)	School mackerel			
East Coast Inshore Fin Fish (QLD)	Tailor			
East Coast Inshore Fin Fish (QLD)	Grunter			
East Coast Inshore Fin Fish (QLD)	Dart			
East Coast Inshore Fin Fish (QLD)	Bream			

Fishery	Underutilised species	Harvest challenges/opportunities	Processing Challenges/opportunities	Market challenges /opportunities
Fin Fish Trawl (QLD)	Mangrove jack	Demersal otter trawl and Danish seine net. Approximately 19% of the total landed catch in 2009 was byproduct.		
Gulf of Carpentaria Inshore Fin Fish (QLD)	Rays	Set mesh gillnets, bait mesh gillnets, cast nets.		
Rocky Reef Fin Fish (QLD)	Amberjack	Hook and line.		
Rocky Reef Fin Fish (QLD)	Mahi mahi			
Rocky Reef Fin Fish (QLD)	Samsonfish			
Rocky Reef Fin Fish (QLD)	Sea sweep			
Rocky Reef Fin Fish (QLD)	Grass sweetlip			
Rocky Reef Fin Fish (QLD)	Frypan bream			
Rocky Reef Fin Fish (QLD)	Pearl perch			
Rocky Reef Fin Fish (QLD)	Teraglin			
South Coast wetline/trap/crustacean	Hammerhead shark		Grey flesh	Featured in Seafood festival Esperance (information sheet produced).
Northern Shark Fishery	Shark (not protected species)	Larger species Opportunity for shark liver (oil etc., 30% of fish)	Boat carrying capacity (to manage logistics) in isolated areas	Aust not Asian shark fin market
Western Deep Sea Fishery	Ghost shark	Little data		
GAB	Angel shark @			
GAB	Gummy shark	1717 quota		
Barramundi (NT)	Blacktip shark			
Demersal (NT)	Small shark species ???			
Offshore Net and Line (NT)	Other shark species? 294t in 2012 ???	Longline, pelagic gillnets		

Fishery	Underutilised species	Harvest challenges/opportunities	Processing Challenges/opportunities	Market challenges /opportunities
Ocean Trap & Line (NSW)	Sharks ???			
East Coast Inshore Fin Fish (QLD)	Shark ???			
Gulf of Carpentaria Inshore Fin Fish (QLD)	Sharks ???			
Gulf of Carpentaria Inshore Fin Fish (QLD)	Tropical shark ???			