Western Rock Lobster Research Network

Research Priorities and Business Plan

FINAL

October 2021

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Preamble

Navigating challenges and opportunities and giving effect to change is not new territory for our industry.

Over the course of its approximate 100-year history, fishers, processors, financiers, researchers and regulators have worked together to develop and implement new ways of fishing, managing the natural resource and capitalising on market opportunities. Despite turbulent times throughout this history, the western rock lobster industry continues to be recognised globally for its sustainability and highly sought-after premium product.

The investment in scientific research that has enabled this is significant, particularly as it relates to establishing and maintaining the Western rock lobster fishery's Marine Stewardship Council (MSC) accreditation. The historical research portfolio that relates to the MSC accreditation has led some to form a view that the western rock lobster industry is adequately researched. It is not. In the context of climate change, increasing global competition and rising costs we must continue to make carefully targeted strategic investments in the development of knowledge, decision tools and technology that help us make the resource management, strategic, investment and operating decisions that underpin continued sustainability of our fishery, competitiveness of our products in international markets and profitability of our businesses.

In recent times we have seen the emergence of a range of ecological, political and market threats that have cumulatively resulted in unprecedented challenges – an almost 'perfect storm'. The Western Rock Lobster Council's Risk Register identifies 17 potential catastrophic risks, many of which have materialised (loss of main market, loss of confidence in the quality of product and reduction in Gross Value of Product), or present significant probability of materialising in the short-to-medium term (loss or reduction in funding from government, changes in climate and ocean acidification, seismic survey and drilling, change in puerulus survival and behaviour, under-utilisation of resource resulting in pressure for reallocation and difficulty in accessing capital).

These challenges will continue, just as new opportunities for our industry will emerge. There is no question that current industry conditions place considerable constraint on industry's ability to invest more in research and development. However, in the context of an increasingly complex and dynamic industry and market environment, the need to adopt, at the very least, a more strategic, efficient and effective approach to attaining the knowledge and technology that we need from the compulsory indirect investment the industry currently makes in research and development via the contribution the Western Australian Government makes to the Fisheries Research and Development Corporation (FRDC) derived from the resource access fee cannot be more important.

Finally, in progressing efforts to deliver western rock lobster fishers, processors and other stakeholders a more effective innovation system, we cannot ignore the irrefutable fact that industry investment in research and development and achieving our primary objective of optimal resource access security are intrinsically linked – we need access to world class knowledge to continue to prosecute our case to government and the community, increased investment in local innovation capability contributes to government support and social license to operate but somewhat perversely, industry cannot invest confidently in research unless it has confidence it will be able to adequately fish the natural resource into the future.

This research priorities and business plan for the Western Rock Lobster Research Network sets out the priority areas of research, an enhanced governance and management framework for making research investment decisions and managing research projects and their outcomes. Its primary focus is ensuring that industry gets optimal benefit from its Industry Partnership Agreement (IPA) with the FRDC by ensuring a strategic approach to prioritisation, leveraging the IPA resources against other external funding sources and where appropriate, partnering in research project delivery.

The research priorities, management and governance framework set out in this document have been developed independently through consultation with WRL membership, its board and other stakeholders. I am confident that the strategic approach to investing in research and development that is articulated in this plan will deliver significant benefits to the western rock lobster industry over the short, medium and longer term and look forward to working with WRL members and other stakeholders in the western rock lobster industry in its implementation.

[INSERT SIGNATURE]

Terry Lissiman
Chair
Western Rock Lobster Council Inc.

1.   Introduction and background

1.1.   The western rock lobster industry

The commercial western rock lobster fishery is the largest wild-catch fishery in Australia and the second largest sector of the Australian seafood industry. Accounting for around 65 percent of Western Australian fishing and aquaculture Gross Value of Product (GVP), the western rock lobster industry was the first fishing industry globally to be accredited under the Marine Stewardship Council (MSC).

A highly sought-after premium product in domestic and particularly international markets, the supply chain that delivers live, fresh and frozen product to seafood markets, restaurants and retail outlets across the globe harmoniously shares the resource with a local recreational sector. With the fishing effort based in coastal regional communities from Kalbarri in the north to Augusta in the south, the western rock lobster industry is fundamental to the economic and social fabric of many regional coastal settlements in Western Australia.

1.2.   The Western Rock Lobster Council

Established in 2001, the Western Rock Lobster Council (WRL Council) is the peak industry body for the western rock lobster commercial fishery with its board directly elected from its membership base of over 750 western rock lobster managed fishery license holders. WRL Council performs an important advocacy function, representing the interests of the industry to governments and the community, as well as providing direct services to industry including management of the sector's Industry Partnership Agreement (IPA) with the Fisheries research and Development Corporation (FRDC).

Consistent with the industry's relative GVP, the contribution that the western rock lobster industry makes indirectly through the Western Australian Government to the Fisheries Research and Development Corporation (FRDC) is also significant. Like 14 other sectors, who together with western rock lobster account for around 75 percent of Australian fisheries and aquaculture value, Western Rock Lobster is party to an Industry Partnership Agreement (IPA) with the FRDC that is designed to ensure that, as a major contributor to the FRDC, research and development specifically targeting the needs of the western rock lobster industry benefits from the significant leverage that the FRDC receives from the Commonwealth Government. However, compared to other sectors of the Australian fishing and aquaculture industry, the western rock lobster industry has substantially underperformed in this regard.

With a current value of approximately $1.0 million per annum, the IPA represents funds that are effectively quarantined by the FRDC for investment in research and development pertaining to the western rock lobster industry. These funds are derived in part from the portion of the western rock lobster resource access fee that is paid to the FRDC by the Western Australian Government and in part from matching funds provided by the FRDC. WRL Council is responsible for negotiation with the FRDC on how these funds are invested.

1.3.   The vital importance of science and innovation

Effective investment in research and development that generates knowledge that can be used by industry to support strategic, investment and operational decisions, or to generate new technology is vital to the sustainability, competitiveness and profitability of all primary

industries. The western rock lobster industry is no different to any other primary industry in this regard.

In the context of the western rock lobster industry, continuous research and development is required to:

- Understand and responds to the ever-changing ecosystem that supports the western rock lobster fishery, as well as cumulative impacts on that ecosystem.
- Improve certainty associated with methods used for determining sustainable and economically optimal levels of harvest of that natural resource.
- Improving the productivity and safety and therefore, competitiveness and profitability of the fishing effort and downstream processes.
- Ensuring strong, evidence-based cases can be made to government and communities that underpin resource access security for the industry.
- Understanding and being able to respond to changes in market and industry conditions.

Importantly, research developing this knowledge must remain targeted on achieving outcomes that are aligned with the specific knowledge needs of industry and produce knowledge, decision-tools and technologies that can be effectively adopted and used by industry.

1.4.   The Western Rock Lobster Research Network

For some time, the WRL Council has espoused significant concern that the direct and indirect investment that the western rock lobster industry makes in research and development is not adequately effective – the process of identifying specific research requirements, designing and assembling projects, organising the resourcing of those projects and managing projects and outcomes has been inefficient and cumbersome.

WRL Council has investigated different options for addressing these concerns, including initially the proposed Australasian Institute for Spiny Lobster Research[1]and then in the process that led to the proposed WRL Research Network, various other mechanisms including outsourcing the research function and collaborating with the wider Western Australian fishing industry in a potential Western Australian Fishing and Aquaculture Research Institute. While these more robust, formalised institutional models may demonstrate merit in the not too distant future, it is clear that a less administrative resource intensive approach is necessary in the immediate term to produce more immediate results for WRL members and the wider western rock lobster fishing industry.

As either a permanent or interim measure, the proposed WRL Research Network will achieve this by:

- Setting very clear, agreed research priorities for the western rock lobster industry
- Putting in place a robust governance process for making decisions pertaining to investments in research though the WRL IPA and potentially other mechanisms
- Deploying professional research management to work collaboratively with industry, other stakeholders, FRDC and other research funders and research organisations to design research projects, assemble research teams, manage the implementation of research projects, and ensure their outcomes are delivered to industry and other stakeholders.

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[1] Australian Venture Consultants (2021), *Australasian Institute for Spiny (Rock) Lobster Research: A Concept Study*, Western Rock Lobster Council

1.4.1. What is the Western Rock Lobster Research Network?

The Western Rock Lobster Research Network (WRL Research Network) will be established and operate as an internal business unit of the WRL Council.

As summarised in Figure 1 below, the WRL Research Network has three key components – WRL Research Priorities Plan, governance framework and executive function.

WRL Research Priorities Plan	Summarised in Section 2 and detailed in Section 3, the WRL Research Priorities Plan identifies and prioritises areas for research investment for the western rock lobster industry. Established through extensive consultation, and subject only unforeseen changes in circumstance that require an urgent research response, WRL will be bound to only invest in the research priorities identified in the WRL Research Priorities Plan.
WRL Research Network Governance Framework	Set out in Section 4, the WRL Research Network Governance Framework is a decision-making process to be established within WRL that is designed to ensure effective, efficient and transparent decision-making with respect to research project investment and management. The WRL Research Network Governance Framework is designed to ensure that the elected board of WRL maintains control of research investment, but its decisions are informed by a diverse set of multidisciplinary expertise and stakeholders in the form of an WRL Research Network Advisory Group.
WRL Research Network Executive Function	Reporting to the CEO and with accountabilities to the WRL Research Network Advisory Group and WRL Board, a WRL Research Network Director will be appointed. This position will be filled by a experienced research manager and will have the responsibility of establishing the WRL Research Network and prosecuting the priorities of WRL Research Priorities Plan including facilitation of research investment decision-making and working with WRL members, other industry, research organisations, research funders and other stakeholders to design project, assemble project teams, marshal project resources and manage project implementation, completion and translation of outcomes.

FIGURE 1 – KEY COMPONENTS OF THE WESTERN ROCK LOBSTER RESEARCH NETWORK

1.4.2. How has the Western Rock Lobster Research Network been developed?

The WRL Research Network has been developed over the course of 12 months and has included:

- **Preliminary consultation**
  In order to determine the research issues that are important to industry semi-structured interviews were undertaken with 42 fishers, processors, researchers, research funders, regulators and other stakeholders and experts. The outcome of this preliminary consultation was the identification of 50 specific research areas deemed to be of importance, organised according to research priorities framework set out in Section 2.

- **State-of-the-art review**
  To ensure that any future research that might be undertaken with respect to the 49 specific research areas identified in the preliminary consultation and to identify scope for future valuable research in those areas, a literature review was undertaken, assessing over 130 publications whose primary research outcomes are targeted at those research areas. This state-of-the-art review is contained in Appendix 1.

- **Consultation working draft**
  The outcomes of the preliminary consultation and state-of-the-art review were synthesised into a Consultation Working Draft. This document describes the background to the proposed WRL Research Network, identifies contemporary

issues facing the western rock lobster industry, details the research priorities framework, identified research areas and the state-of-the-art review and provides a number of options as to structures that could be deployed to give effect to the proposed WRL Research Network. This document was provided to individuals and organisations that were interviewed in the preliminary consultation, the WRL board and other key stakeholders for feedback and comment.

- **Final consultation draft**
  Based on the feedback provided on the Consultation Working Draft, this final consultation draft has prioritised the identified research areas using the methodology described in Section 2, both across the entire research priority framework and within each of the themes and details a governance and management structure for implementing and operating the WRL Research Network.

1.4.3.   The purpose of this final consultation draft

The purpose of this consultation draft is to present the final proposed Research Priorities Plan, governance framework and operating model for the consideration of the full WRL Council membership.

Subject to that feedback, the proposal contained herein will be presented to the WRL Board for final consideration and if appropriate formal adoption.

2. The Western Rock Lobster Research Priorities Plan

This section 2 sets out the Western Rock Lobster Research Priorities Framework, explains the process used to priorities research areas within that framework and identifies the priority research areas accordingly. Details of the prioritisation within the specific themes and programs that comprise the framework, as well as descriptions of the specific research areas are discussed in Section 3.

2.1. The Western Rock Lobster Research Priorities Framework

Derived from the consultation discussed in Section 1.4.2, the Western Rock Lobster Research Priorities Framework organises identified research areas according to six themes and various programmes under each theme in a logic sequence of knowledge acquisition that is required to resolve the questions, address the issues and deliver the practical outcome summarised in the following Figure 2.

FIGURE 2 – WESTERN ROCK LOBSTER RESEARCH PRIORITIES PLAN – SEQUENCE OF KNOWLEDGE ACQUISITION

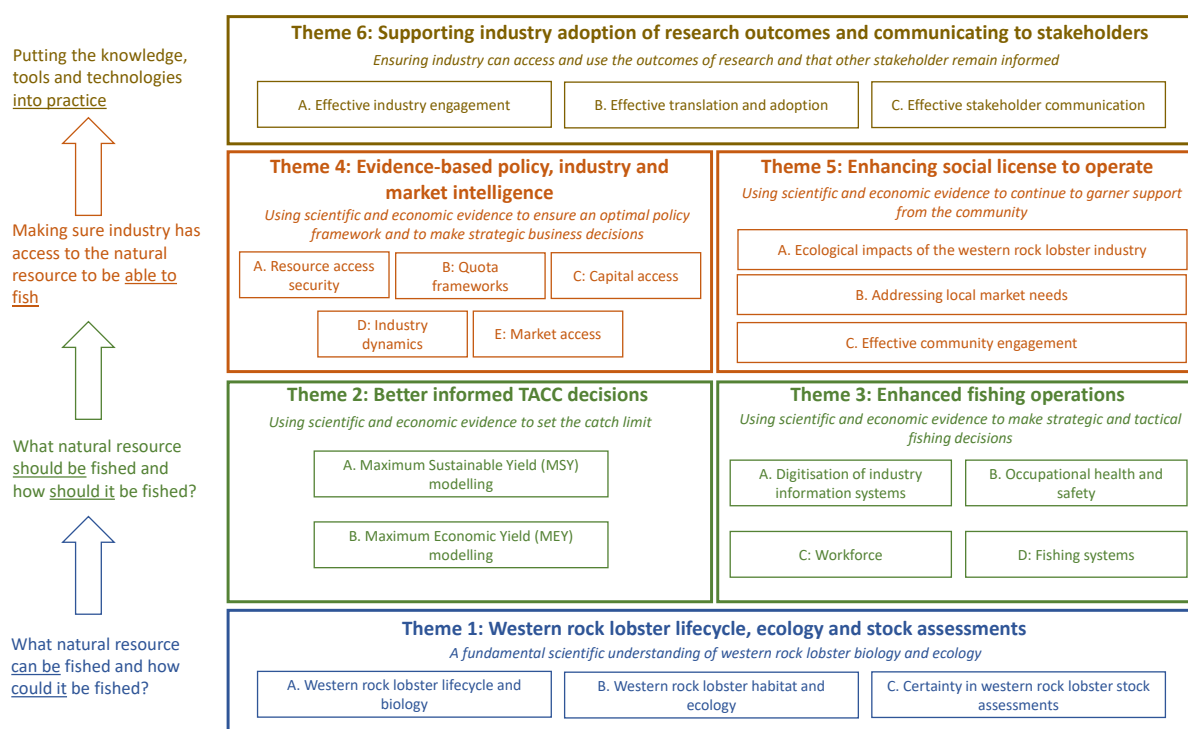The Western Rock Lobster Research Priorities Framework is illustrated in the following Figure 3.

FIGURE 3 – WESTERN ROCK LOBSTER RESEARCH PRIORITIES FRAMEWORK

2.2.   The research priorities

2.2.1.   Prioritisation process

The research priorities framework discussed in Section 2.1 is comprised of six themes and 20 programmes across those themes. The consultation process identified approximately 50 research areas across those programmes. In an environment characterised by scarce resources, a process of further prioritisation is required to ensure prudent investment and optimal outcomes for industry.

This further prioritisation has been given effect by a 'state-of-the-art' analysis and a further triaging process.

State-of-the-art analysis

The Consultation Working Draft includes a review of literature pertaining to each of the research areas identified under the themes and programmes that comprise the research priorities identified in the Consultation Working Draft. This provides an indication as to the status of knowledge (or 'state-of-the-art') pertaining to a particular research area and assists in prioritisation by ensuring that any research conducted under the WRL Research Network is not unnecessarily duplicative and is in fact advancing toward a solution. The state-of-the-art analysis is contained in Appendix 1.

Prioritisation triage

Because they are identified by western rock lobster fishers, processors and other key stakeholders as important issues requiring further knowledge to resolve, all of the research areas identified in the Consultation Working Draft are important. However, as a result of scarce resources, not all of the identified research areas can be addressed at once and in some instances, there are potentially more efficient ways of addressing a research area through collaborations or by leveraging of research being undertaken as a priority by other organisations.

To this end, the priority research areas identified in the framework are further triaged according to the following dimensions.

1. **Criticality**
   Criticality refers to the extent to which developing new knowledge, decision tool or technology under an identified research area is important to the continuity, productivity or profitability of the industry. This can include research areas that challenge-oriented in the form of threats, or opportunity-oriented in the form of pathways for enhancing value for industry. Across this dimension, research areas can reside on a continuum from low to high criticality.

2. **Urgency**
   Urgency refers to the timeframe that new knowledge, decision tool or technology to developed under an identified research area needs to be realised in order to optimally address an identified challenge or opportunity. Across this dimension, research areas can reside on a continuum from low to high urgency.

3. **Opportunities to collaborate with or leverage from others**
   In some instance identified research areas are such that western rock lobster will have a shared, non-competitive interest in the research outcome with government, other sectors of the fishery, other industries and mission-oriented research organisations. In

such circumstances, the WRL Research Network can leverage its resources to achieve more efficient research outcomes. This can include significant co-investment where interests are more or less equal, to less significant input and outcome sharing where the area is a major research focus of another organisation. Across this dimension, research areas can be classified as principally the responsibility of WRL (Red), a shared responsibility with another entity (brown), a major focus of another entity (green).

This prioritisation landscape is illustrated in the following Figure 4.
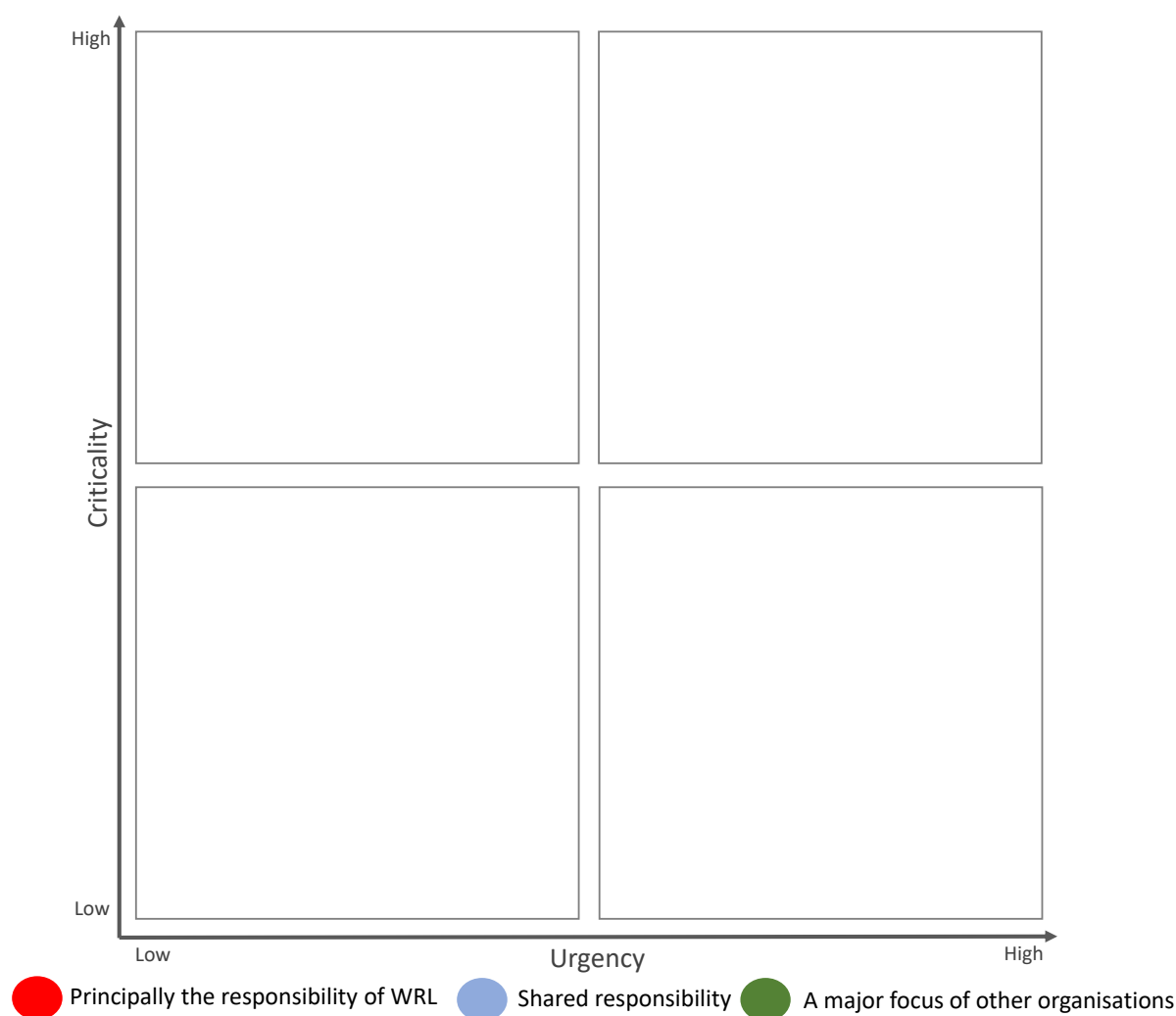
FIGURE 4 – WRL RESEARCH PRIORITISATION LANDSCAPE

2.2.2.   The research priorities

This subsection sets out the research areas, triaged in accordance with the prioritisation framework discussed in Section 2.2.1. Prioritisation within each theme and programme, together with details on each research area are discussed in Section 3.

High priority: research areas of high criticality and high urgency

Over half of the research areas identified in the research priorities plan have been deemed to be critical issues requiring urgency in their resolution. Approximately two-thirds of these research areas have shared responsibility with other organisations such as DPIRD, Recfishwest,

or the processing sector. Only one of the research areas in this highest priority classification is the primary responsibility of another organisation.

The following Table 1 lists the research areas that are identified as being of high criticality and high urgency.

TABLE 1 – HIGH CRITICALITY AND HIGH URGENCY RESEARCH AREAS

Program	Research Area	Category
Theme 1: Western rock lobster lifecycle, ecology and stock assessments		
Programme A: Western rock lobster lifecycle and biology	Toward and evidence-based understanding of western rock lobster migration	🔵
Programme B: Western rock lobster habitat and ecology	Impact of seismic surveys on the western rock lobster lifecycle	🔴
Programme C: Certainty in stock assessments	Shared responsibility for stock assessments	🔵
	Certainty in assessment of the recreational catch	🔵
Program	**Research Area**	**Category**
Theme 2: Better informed TACC decisions		
Programme A: Optimising maximum sustainable yield (MSY) modelling	Evidence-based case for MSY v MEY determination of TACC	🔴
Programme B: Optimising maximum economic yield (MEY) modelling	MEY and DPIRD's new statutory responsibilities	🔵
	Enhanced MEY algorithms	🔴
Program	**Research Area**	**Category**
Theme 3: Enhanced fishing operations		
Programme A: Digitisation of industry information systems	Modernisation of the DPIRD industry administrative interface	🔵
	Access to DPIRD data for supply chain decision-making	🔵
Programme C: Workforce	Accreditation of the lobster fishing skillset	🟢
Programme D: Fishing systems	Developing systems that optimise lobster welfare	🔴
Program	**Research Area**	**Category**
Theme 4: Evidence-based policy, industry and market intelligence		
Programme A: Resource access security	Maintaining thought leadership	🔴
Programme B: Quota frameworks	Assessment of the case for split quotas	🔵
	Toward cross sector quota trading	🔵
Programme C: Capital access	Industry financial benchmarking	🔴
	Unit registry reform	🔴
Programme D: Market access	Market intelligence	🔵
	Residue testing	🔵
Program	**Research Area**	**Category**
Theme 5: Enhancing social licence to operate		
Programme A: Ecological impacts of the western rock lobster industry	Plastics reduction in fishing gear	🔵
Programme B: Local market access	Understanding local market lobster demand dynamics	🔵
Programme C: Effective community engagement	Effective engagement with the recreational sector	🔵
	Effective engagement with local fishing communities	🔴

Medium priority: research areas of high criticality and low urgency

Research areas that have been deemed to be of high criticality, but low urgency can be considered issues of medium priority. They address areas which are ultimately critical to industry continuity, productivity or profitability, but which relatively speaking do not require urgent resolution because they are conditional on another research outcome, address a 'slow-burn' issue or deliver knowledge that is not immediately actionable from a practical perspective.

Whilst a relatively small set of priorities, all but one of the research areas in this category are a shared responsibility with DPIRD, processors or vessel manufacturers.

The following Table 2 lists the research areas that have been categorised as a medium priority.

TABLE 2 - HIGH CRITICALITY AND LOW URGENCY RESEARCH AREAS

Program	Research Area	Category
Theme 1: Western rock lobster lifecycle, ecology and stock assessments		
Program B: Western rock lobster habitat and ecology	Enhanced prediction of warm water events and effects on the biomass	🟢
	Enhanced prediction of currents	🟢
Program C: Certainty in stock assessments	Integrating enhanced understanding of impacts on western rock lobster lifecycle, habitat and ecology into predictive modelling	🔵
Program	Research Area	Category
Theme 3: Enhanced fishing operations		
Programme A: Digitisation of industry information systems	Scoping an online quota trading platform	🔵
	Provenance traceability for processed production	🔵
Programme B: Occupational health and safety	Accredited lobster fishing OHS induction course	🔵
Programme C: Workforce	Training in ICT systems	🟢
Program	Research Area	Category
Theme 5: Enhancing social licence to operate		
Programme A: Ecological impacts of the western rock lobster industry	Reducing the fishing fleet carbon footprint	🔵
	Impact of the fishing effort on megafauna	🔵

Medium priority: research areas of low criticality but high urgency

Research areas that have been deemed to be of low criticality, but high urgency can be considered issues of medium priority. They address issues that are ever-present and therefore require an urgent solution, but relatively speaking are not critical with respect to industry continuity, productivity or profitability. They are not considered a high priority because their impact on industry continuity, productivity or profitability will be incremental or because there are limited if any management actions that can be taken to address them.

This is also a relatively small category, with all but one of the identified issues being the primary responsibility of another organisation, either major scientific research organisations such as CSIRO and UWA, or health organisations.

The following Table 3 lists the research areas that are deemed to be of high urgency, but low criticality.

TABLE 3 – LOW CRITICALITY, HIGH URGENCY RESEARCH AREAS

Program	Research Area	Category
Theme 1: Western rock lobster lifecycle, ecology and stock assessments		
Program C: Certainty in stock assessments	Increased geographic resolution of puerulus surveys	🔵
	Innovation in stock assessment methods	🔵

Low priority: research areas of low criticality and low urgency

While still research priorities, within the priority framework research areas in this category are of relatively low priority. Compared to other identified research areas, their resolution will have

less of an impact on the continuity of the industry, its productivity and profitability and do not require urgent resolution.

This list comprises around one-quarter of the research areas identified in the research priorities framework. Just under half are shared responsibilities with other organisations or stakeholders, around one-quarter are the primary responsibility of WRL and just under one-quarter are the primary responsibility of another organisation or stakeholder.

TABLE 4 - LOW CRITICALITY LOW URGENCY RESEARCH AREAS

Program	Research Area	Category
Theme 1: Western rock lobster lifecycle, ecology and stock assessments		
Program A: Western rock lobster lifecycle and biology	Do puerulus settle in deep water?	🔵
	Understanding the connection between the lifecycle of northern and southern western rock lobster populations	🔵
	Causes and mitigation of cotton-tail in the lobster catch	🔴
Program B: Western rock lobster habitat and ecology	Scope of potential application of Traditional Ecological Knowledge to inshore rock lobster research	🔴
	Vulnerability of the western rock lobster fishery to ocean acidification	🟢
	River mouths and productivity in the western rock lobster fishery	🔵
	Impact of microplastics on the western rock lobster fishery	🟢
	Snapper and the western rock lobster food web	🟢
Program	**Research Area**	**Category**
Theme 2: Better informed TACC decisions		
Programme B: Optimising Maximum Economic Yield (MEY) modelling	Setting the recreational catch according to maximum social yield	🔵
Program	**Research Area**	**Category**
Theme 3: Enhanced fishing operations		
Programme A: Digitisation of industry information systems	Automated lobster measuring systems	🔴
Programme B: Occupational health and safety	Development of an industry mental health programme	🟢
Program	**Research Area**	**Category**
Theme 4: Evidence-based policy, industry and market intelligence		
Programme D: Market access	Geographic traceability within the fishery	🔴
Programme E: Industry dynamics	Monitoring and reporting on industry dynamics	🔴

3.   Research Priorities by Theme and Programme

This Section 3 sets out the prioritisation of research areas in accordance with the triage framework discussed in Section 2.2.1 for each theme and programme under the WRL Research Priorities Framework.

The description of high criticality and high urgency research priorities are included in this section, with all additional research priorities detailed in Appendix 1.

3.1. Theme 1: Western rock lobster lifecycle, ecology and stock assessments

3.1.1. Theme 1: Programme A: Western rock lobster lifecycle and biology

The following Figure 5 illustrates the determined priorities within Theme 1 Programme A.
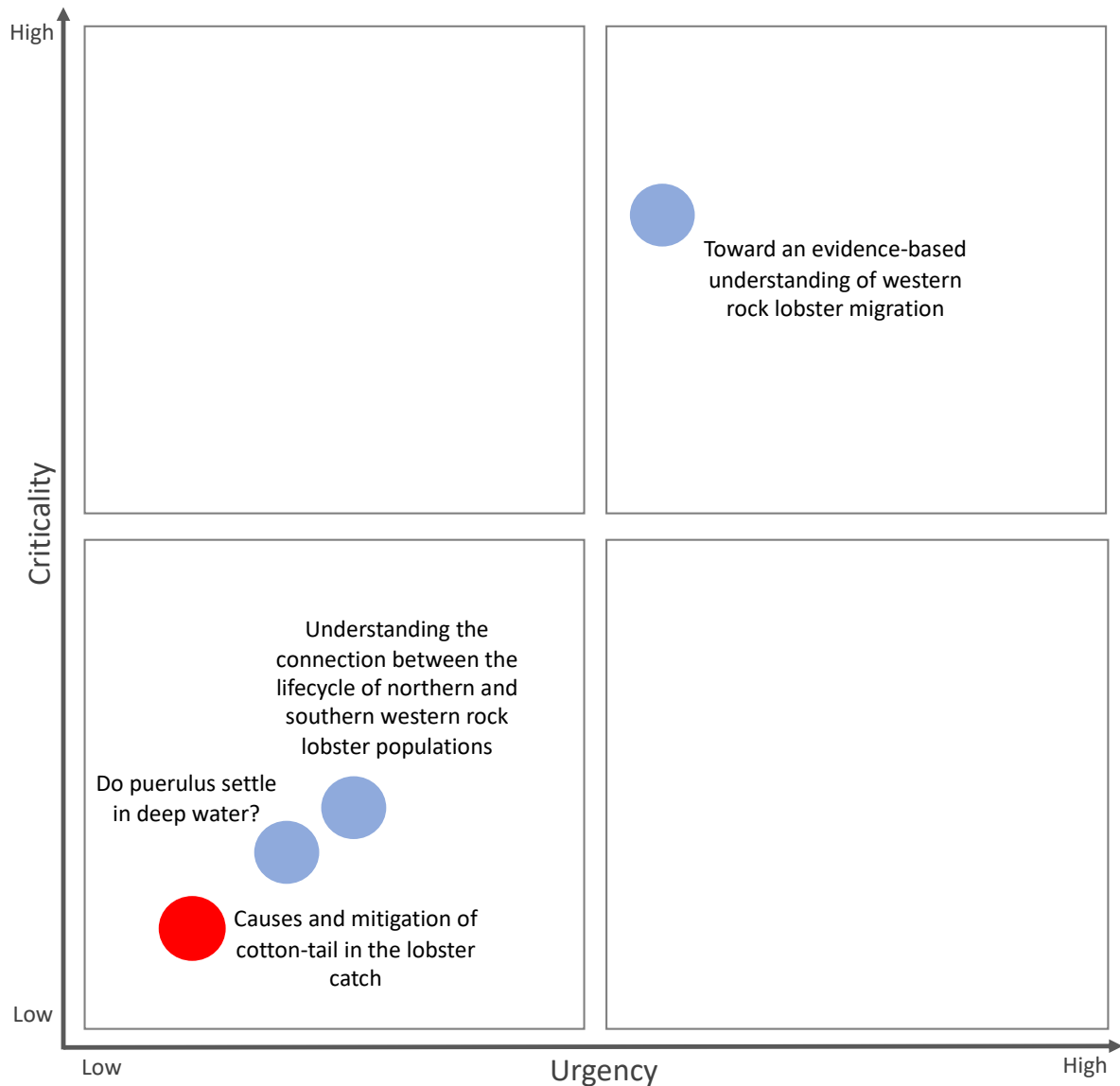
FIGURE 5 - PRIORITISATION OF RESEARCH AREAS IN THEME 1 PROGRAMME A: WESTERN ROCK LOBSTER LIFECYCLE AND BIOLOGY

The following Table 5 summarises the high criticality and high urgency research programs that are prioritised in the above **Error! Reference source not found.**, with other research priorities detailed in Appendix 1.

Research Areas

Toward an evidence-based understanding of western rock lobster migration

While there is an understanding of the destination of western rock lobster in their annual 'whites' migration run, the precise pathway(s) that are taken and events that may occur along that migration pathway are not understood. An evidence-based, more detailed understanding of migration pathway(s) and factors that impact on that pathway will inform both tactical fishing decisions and provide a broader understanding of ecological factors that may impact on western rock lobster lifecycle. For example, what impacts do quota changes have on the balance of whites and reds caught and what is the optimal balance of catching migrating whites versus reds for the fishery.

Given its importance to fishing productivity and understanding and managing cumulative impacts on the fishery, this research area is considered to demonstrate a high level of criticality and moderate to high urgency. Furthermore, given its relevance to fishery management decisions, it should also be an area of research that is of importance to DPIRD. Potential collaborators in research in this area include UWA and CSIRO.

3.1.2. Theme 1 Programme B: western rock lobster habitat and ecology

The following Figure 6 illustrates the determined priorities within Theme 1 Programme B.
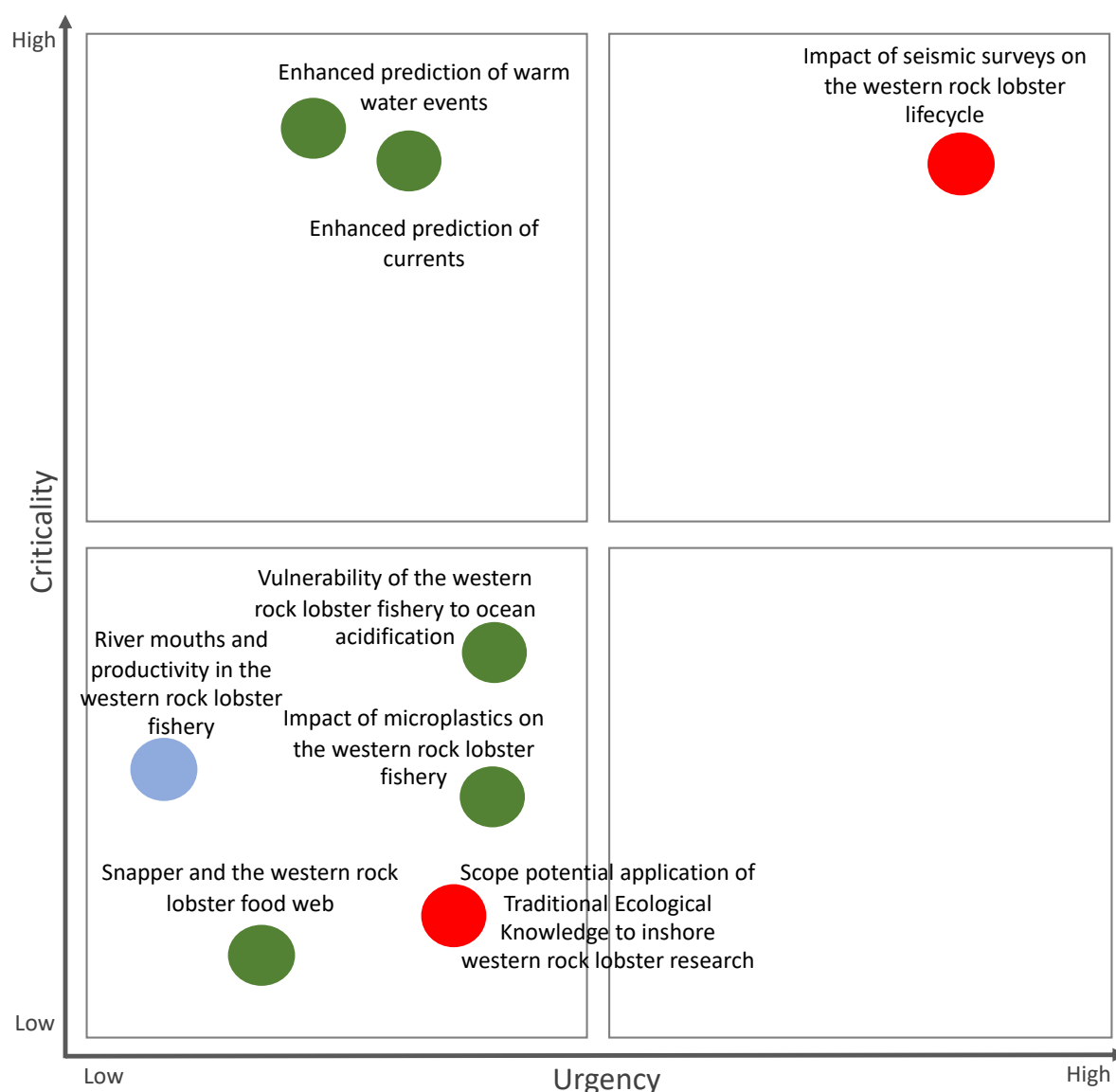
FIGURE 6 – PRIORITISATION OF RESEARCH AREAS IN THEME 1 PROGRAMME B: WESTERN ROCK LOBSTER HABITAT AND ECOLOGY

The following Table 6 summarises the high criticality and high urgency research programmes that are prioritised in the above Figure 6, with other research priorities detailed in Appendix 1.

TABLE 6 - THEME 1 PROGRAMME B: WESTERN ROCK LOBSTER HABITAT AND ECOLOGY

Research Areas

Impact of seismic surveys on the western rock lobster life cycle

The impact of seismic survey operations conducted by the offshore oil and gas industry on the lifecycle of various commercial fishery species has been the focus of research in areas across the globe where petroleum prospective offshore basins intersect with areas that important for supporting the lifecycle of commercially fished species.

The nature of this interaction is unique to every circumstance based on the specific species, the stage of lifecycle impacted, frequency and nature of seismic survey and specific oceanography. In the case of western rock lobster, its significant migratory footprint at various stages of its lifecycle and the intensity of seismic survey along the Western Australian coast, particularly in the Carnarvon and increasingly, Perth Basins, arguably make its circumstance particularly unique.

An evidence-based scientific understanding of the specific impact of offshore seismic surveys on the western rock lobster lifecycle is important for informing predictive stock models, tactical fishing decisions, fishing investment decisions and ultimately rights to compensation for loss of access to the fishery that may result from seismic survey activity. Furthermore, offshore petroleum exploration is increasing in areas adjacent to and within the western rock lobster fishery. For these reasons, this area of research is considered to be of high criticality and urgency and is primarily the responsibility of WRL – while SRL has also conducted some work in this area, the intensity of oil and gas exploration in offshore Western Australia and uniqueness of the bathymetry and marine ecosystem means that very focused work is likely required for Western Rock Lobster.

3.1.3. Theme 1 Programme C: Certainty in stock assessments

The following Figure 7 illustrates the determined priorities within Theme 1 Programme C.
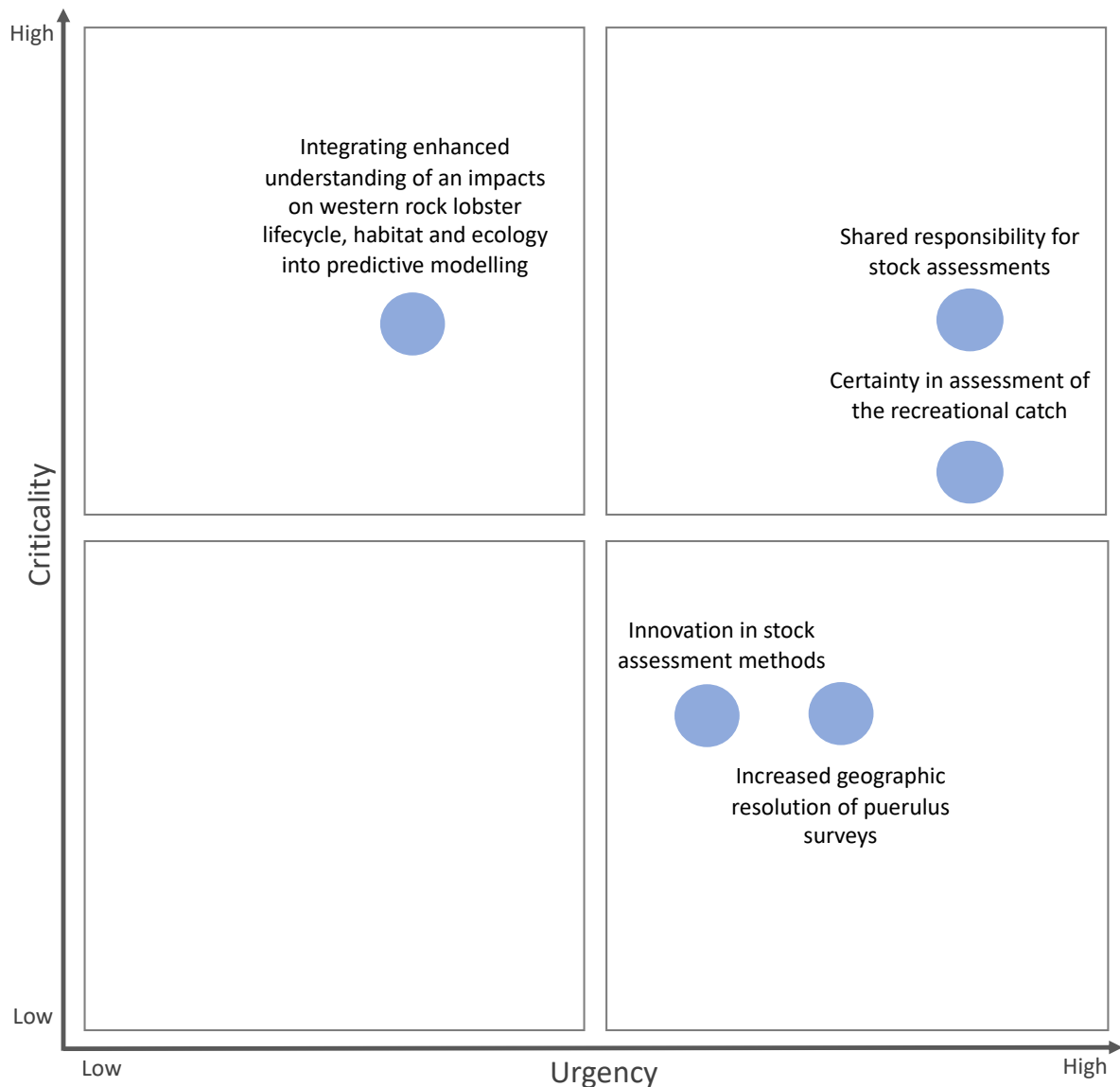
The following Table 7 summarises the high criticality and high urgency research programmes that are prioritised in the above Figure 7, with other research priorities detailed in Appendix 1.

TABLE 7 - THEME 1 PROGRAMME C: CERTAINTY IN STOCK ASSESSMENTS

Research Areas

Certainty in assessment of the recreational catch

The number of western rock lobster taken by the recreational sector is a significant component of the Total Allowable Catch and impacts on the sustainability of the fishery. Whereby the commercial catch is accurately monitored and measured, assessment of the recreational take is measured by surveys of recreational fishers and some periodic and *ad hoc* monitoring at recreational boat ramps.

Significantly greater accuracy in the measurement of the recreational catch could be achieved through the development of a mobile phone application that uses real-time data entry, digital imaging, GIS and potentially block-chain technology that is linked to individual recreational licenses to monitor the recreational catch in real time with much greater accuracy.

Greater certainty as to the number of lobsters taken throughout a season at different locations would provide greater certainty in managing the sustainability of the resource and provide a platform for potential migration toward quota trading between the sectors. This data could also be used to better inform predictive stock assessment models.

Uncertainty with respect to the recreational catch is potentially a major point of inaccuracy in stock assessments. Therefore, improving the accuracy of the assessment of the recreational catch is a critical issue that requires relatively urgent resolution. However, this is a responsibility that is shared with the recreational sector (Recfishwest) and DPIRD. Additional potential partners in this program include UWA and CSIRO. Further if the solution is to include mobile phone applications Edith Cowan University and private sector mobile application development may also be suitable partners.

Shared responsibility for stock assessments

The stock observations of fisherman who interact with the natural resource on an almost daily basis is a potentially rich source of additional information on the status of the resource and ecological and other factors that influence stocks. DPIRD currently utilise relationships with some fishers to conduct surveys. However, a broader and deeper relationship regarding the collection of measured and observational data and discussion of various aspects of stock assessment and its outputs with industry would likely lead to enhanced outcomes.

This issue is a shared responsibility with DPIRD and is considered by industry to be an issue of high criticality and urgency.

3.2.   Theme 2: Better informed TACC decisions

3.2.1.   Theme 2 Programme A: Optimising maximum sustainable yield (MSY) modelling

The following Figure 8 illustrates the determined priorities within Theme 2 Programme A.

Evidenced-based case for MSY v MEY determination of TACC

High

Criticality

Low

Low   Urgency   High

🔴 Principally the responsibility of WRL   🔵 Shared responsibility   🟢 A major focus of other organisations
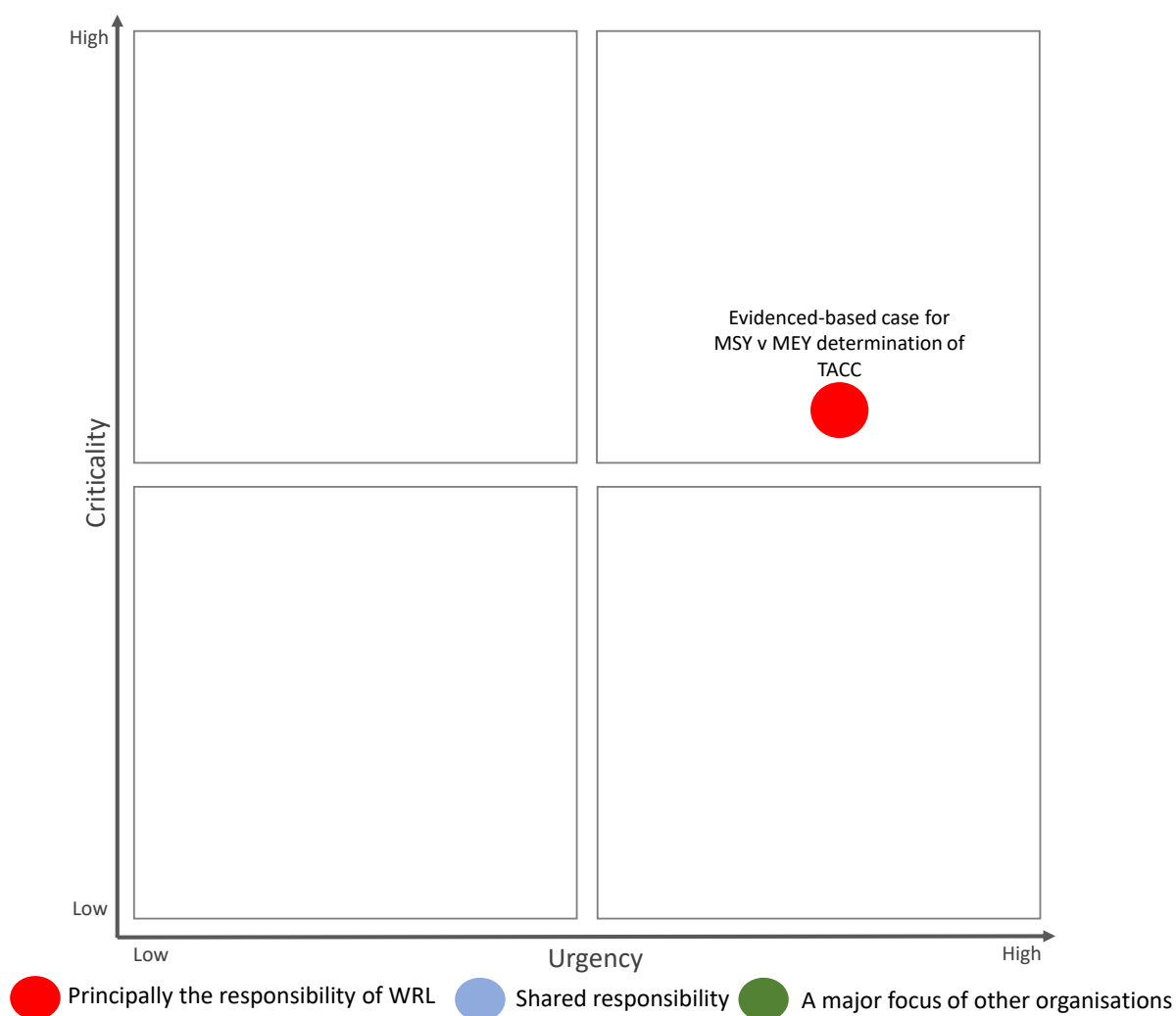
FIGURE 8 – PRIORITISATION OF RESEARCH AREAS IN THEME 2 PROGRAMME A: OPTIMISING MAXIMUM SUSTAINABLE YIELD (MSY) MODELLING

The following Table 8 summarises the high criticality and high urgency research programmes that are prioritised in the above Figure 8.

TABLE 8 - THEME 2 PROGRAMME A: OPTIMISING MAXIMUM SUSTAINABLE YIELD (MSY) MODELLING

Research Areas

Evidence-based case for MSY v MEY determination of TACC

The recent decline in price for western rock lobster that is the result of the suspension of exports to the PRC has led to some to call for the TACC to be set at or close to the MSY. This argument is based on two logics. The first is that without the premium pricing attainable in the PRC market, Australian lobster will trend away from being a luxury product towards commoditisation and therefore fishing business returns will be increasingly driven by volume. The second is that, setting TACC against MEY in current market conditions means that the commercial sector is fishing substantially below MSY, creating a potential case for reallocation of the resource to the benefit of the recreational, customary and charter sectors.

These arguments are countered by the notion that, subject to the robustness of the MEY model, TACC set against MEY will deliver the best economic outcome for industry and in almost all circumstances

the best conservation outcome. Developing an evidence-based argument on this issue and market-based re-allocation process will be important for protecting industry's interests.

This issue is considered to be of medium-to-high criticality and urgency and is primarily a WRL responsibility.

3.2.2. Theme 2 Programme B: Optimising maximum economic yield (MEY) modelling

The following Figure 9 illustrates the determined priorities within Theme 2 Programme B.
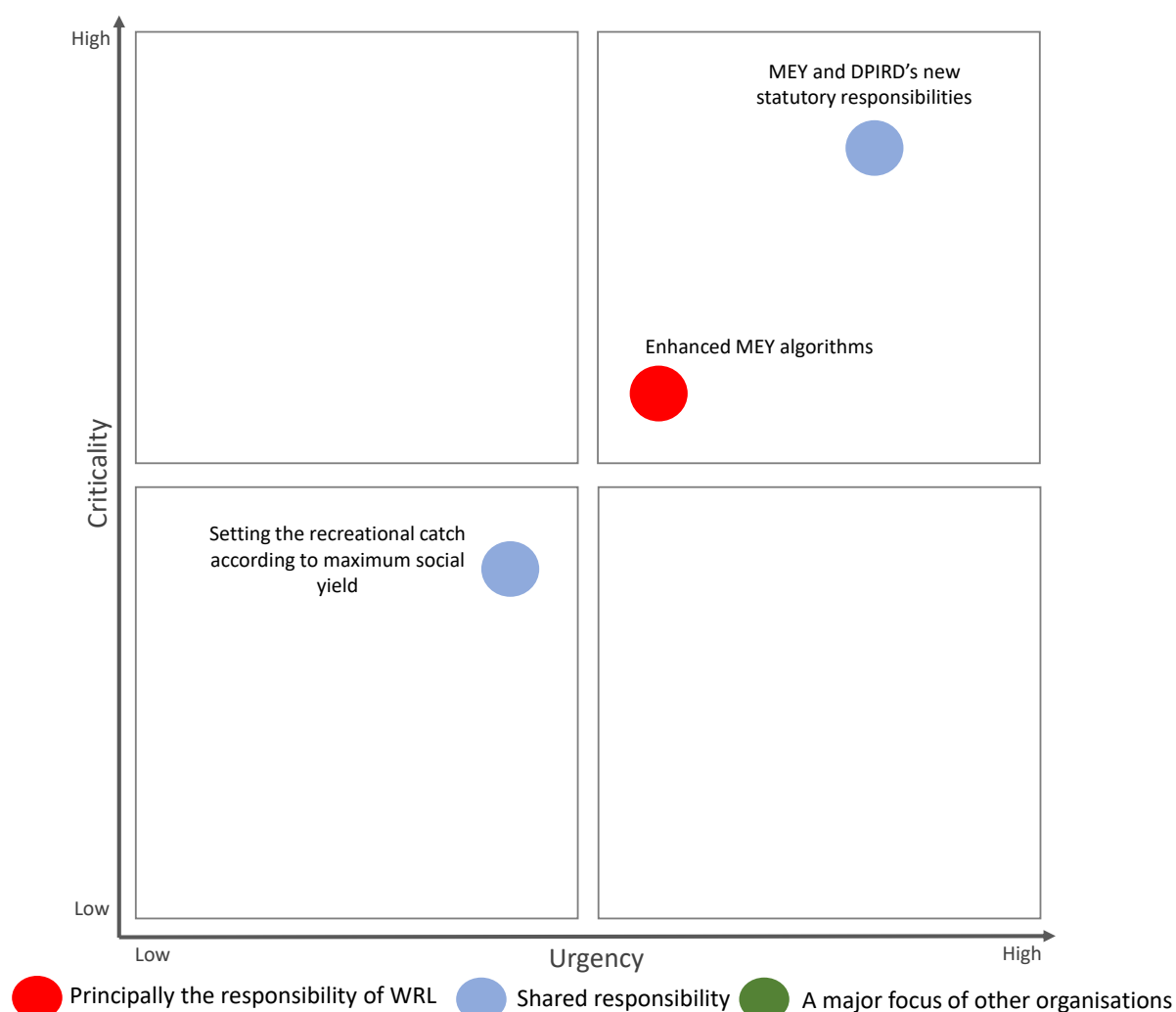
FIGURE 9 – PRIORITISATION OF RESEARCH AREAS IN THEME 2 PROGRAMME B: OPTIMISING MAXIMUM ECONOMIC YIELD (MSY) MODELLING

The following Table 9 summarises the high criticality and high urgency research programs that are prioritised in the above Figure 9, with other research priorities detailed in Appendix 1.

TABLE 9 - THEME 2 PROGRAMME B: OPTIMISING MAXIMUM ECONOMIC YIELD (MEY) MODELLING

Research Areas

MEY and DPIRD's new statutory responsibilities

While DPIRD's primary statutory responsibility will remain as ensuring the sustainability of the natural resource, as industry transitions to regulation under the *Aquatic Resource Management Act 2016* (WA), DPIRD will be compelled, to some degree, to take into account economic issues at least as a secondary consideration in its resource management decisions.

This will likely require the MEY model to take into account DPIRD requirements under the *Aquatic Resource Management Act 2016* (WA), as determined by DPIRD. A determination of these requirements and development of inputs and algorithms that address those requirements will be important to ensure the integrity and usefulness of the MEY model in the new regulatory environment.

This is determined to be an issue of high criticality and urgency and is a shared responsibility with DPIRD. Other potential collaborators include Curtin, UWA, CSIRO and the private sector.

Enhanced MEY algorithms

Ensuring that the MEY is optimally accurate, that its integrity is maintained, that it is adequately robust enough to incorporate and model inputs that impact on its outcome is critically important. Changes in the structure of the industry and responses to changes in stock across the zones will result in changes in fishing strategy and tactics.

The accuracy of the MEY model will be substantially enhanced if it is able to take into account changes in fishing strategies tactics. This issue is considered to be of high criticality, but medium urgency. It is primarily a WRL responsibility and research partners might include SRL, UWA, Curtin, CSIRO, IMAS, DPIRD and the private sector.

3.3. Enhanced fishing operations

3.3.1. Theme 3 Programme A: Digitisation of industry information systems

The following Figure 10 illustrates the determined priorities within Theme 3 Programme A.
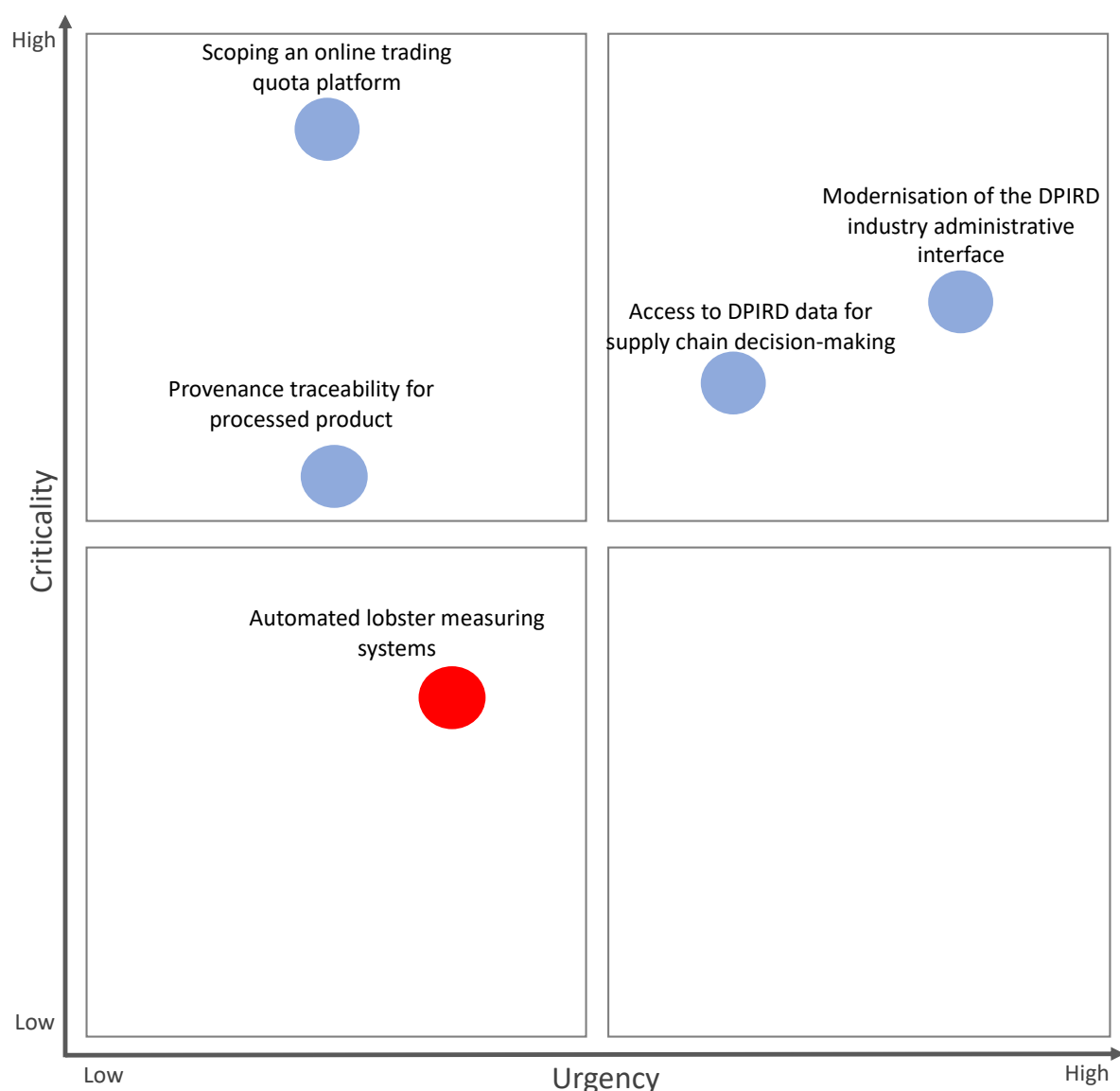
FIGURE 10 – PRIORITISATION OF RESEARCH AREAS IN THEME 3 PROGRAMME A: DIGITISATION OF INDUSTRY INFORMATION SYSTEMS

The following Table 10 summarises the high criticality and high urgency research programs that are prioritised in the above Figure 10, with other research priorities detailed in Appendix 1.

TABLE 10 - THEME 3 PROGRAMME A: DIGITISING OF INDUSTRY INFORMATION SYSTEMS RESEARCH AREAS

Research Areas

Modernisation of the DPIRD industry administrative interface

As a result of both lags in digital infrastructure investment and the merger of three separate operating platforms when DPIRD was formed through the amalgamation of the former Departments of Agriculture, Regional Development and Fisheries, much of the administrative interface between DPIRD and the industry is antiquated and inefficient. This occurs to the extent that presentation of a physical paper cheque is still required to renew fishing licenses.

While modernisation of the DPRID's digital and online systems its entirely a Western Australian Government responsibility and DPIRD is currently in the process of assessing and implementing new

systems, industry has a vested business motivation to ensure those systems deliver optimal administrative certainty and efficiency.

The likelihood of this being the case is optimised by a proactive approach from industry with respect to presenting DPIRD with its administrative systems requirements.

Progressing this issue to a conclusion is considered an issue of high criticality and urgency and is a shared responsibility with DPIRD. Potential collaborators include private sector ICT service companies.

Access to DPIRD data for supply chain decision-making

Currently the efficiency of the western rock lobster supply chain is suboptimal as the result of a range of uncertainties as to fishing effort and outputs in daily supply chain decision, particularly uncertainty as to sizes of catches, times of landing, locations of landing and bait requirements for following days. This uncertainty manifests in suboptimal logistics operations and downstream processes such as frozen production, live pack-outs and daily sales offers.

Data collected by DPIRD through the DPIRD IVR system and FishEye provides a data platform for systems that could be used to better inform supply chains participants on fishing activities, resulting in a decision-making tool that allows supply chain systems to respond in near-real-time to the fishing effort and activities, improving overall industry productivity and profitability. Similarly, DPIRD would benefit from such a system through scope for automation of processes such as reconciliation of reported catch with processed catch.

A study that scopes the nature and usefulness of data generated through the DPIRD IVR, FishEye and other systems in use in western rock lobster supply chain optimisation, potential data governance frameworks, architectures for developing Application Programming Interfaces (API) that allow industry to access the DPIRD data and a business case for development of that architecture and API would present a pathway for enhanced western rock lobster supply chains.

Progressing this issue to a conclusion is considered an issue of high criticality and urgency and is a shared responsibility with DPIRD. Potential collaborators include private sector ICT service companies and the western rock lobster downstream supply chain industry.

3.3.2. Theme 3 Programme B: Occupational health and safety

The following Figure 11 illustrates the determined priorities within Theme 3 Programme B.
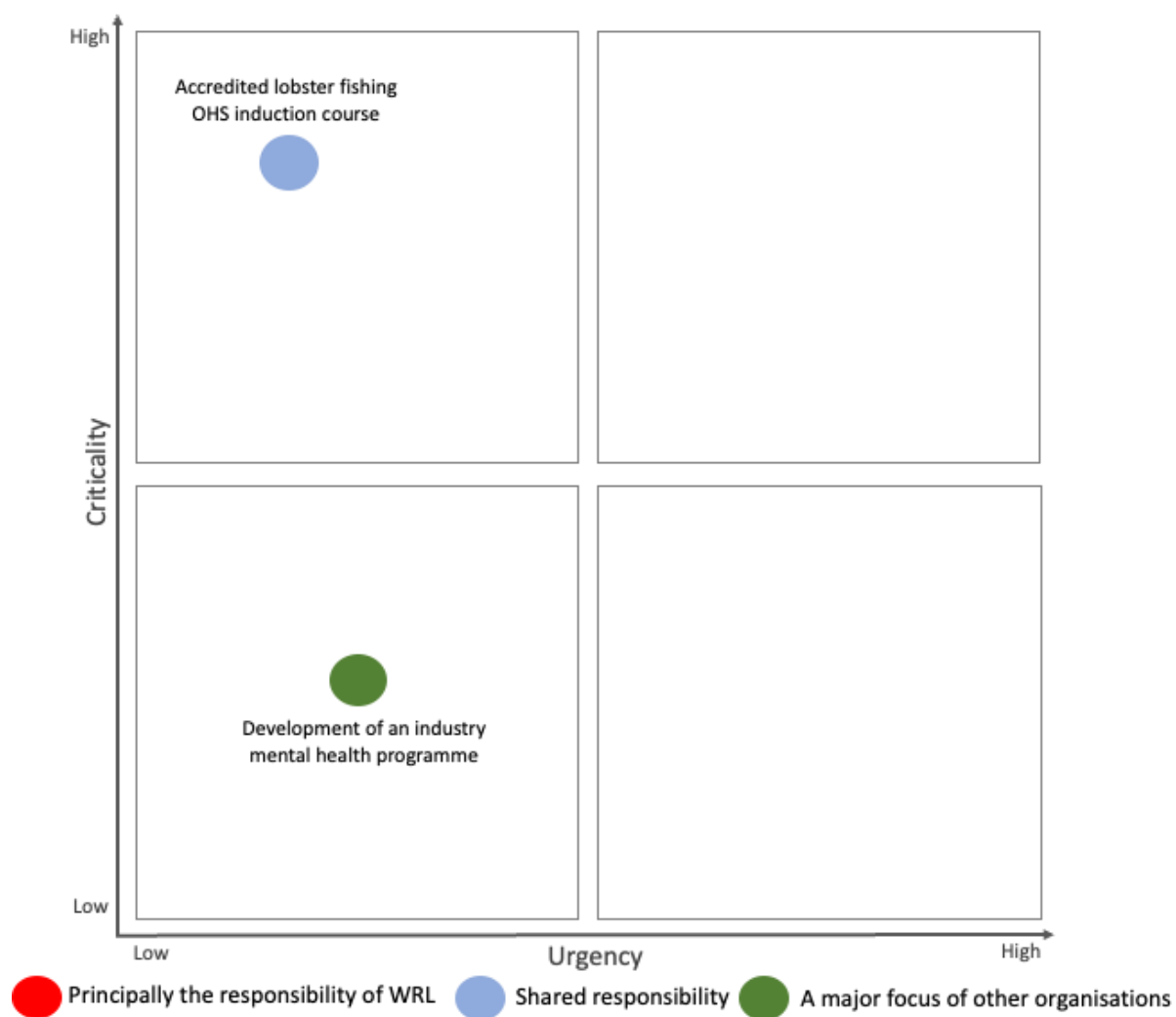
FIGURE 11 – PRIORITISATION OF RESEARCH AREAS IN THEME 3 PROGRAMME B: OCCUPATIONAL HEALTH AND SAFETY

The research priorities illustrated in Figure 11are described in Appendix 1.

3.3.3. Theme 3 Programme C: Workforce development

The following Figure 12 illustrates the determined priorities within Theme 3 Programme C.

High

Accreditation of the lobster
fishing skillset

Training in ICT systems

Criticality

Low

Low   Urgency   High

● Principally the responsibility of WRL   ● Shared responsibility   ● A major focus of other organisations

FIGURE 12 – PRIORITISATION OF RESEARCH AREAS IN THEME 3 PROGRAMME C: WORKFORCE DEVELOPMENT

The following Table 11 summarises the high criticality and high urgency research programs that are prioritised in the above Figure 12.

TABLE 11 - THEME 3 PROGRAMME C: WORKFORCE DEVELOPMENT

PROGRAM C: WORKFORCE DEVELOPMENT

Accreditation of the lobster fishing skillset

Across many sectors of industry, previously 'unlicensed' or 'unaccredited' skill sets are transitioning to a 'licensed' or 'accredited' regime. This is driven by a desire to improve, standardise and certify quality of skills and OHS and to provide a basis for benchmarked remuneration. While lobster fishing shares many of the skill requirements of other commercial fishing operations, it has its own unique skill sets.

In an environment where the master of the vessel is licensed and not the crew, significant risk will accrue to the vessel master. A vessel master will have limited scope to manage the risk with crew under employment conditions without accredited programs.

A study exploring the merits and viability of accreditation of the lobster fishing skillset should be the first stage in exploring the business case for investing in the development of an accreditation program with the vocational education and training sector.

This is considered an issue of high criticality and urgency given the prosecution of vessel Master under ARMA. This would represent a shared responsibility with the TAFE sector or private vocational training organisations.

3.3.4. Theme 3 Programme D: Fishing systems

The following Figure 13 illustrates the determined priorities within Theme 3 Program D.

FIGURE 13 – PRIORITISATION OF RESEARCH AREAS IN THEME 3 PROGRAMME D: FISHING SYSTEMS

The following Table 12 summarises the high criticality and high urgency research programs that are prioritised in the above Figure 13, with other research priorities detailed in Appendix 1.

TABLE 12 - THEME 3 PROGRAMME D: FISHING SYSTEMS

Research Areas

Developing systems that optimise lobster welfare

Addressing escalating market and community concerns with respect to animal welfare has become core business for many livestock and wild-catch oriented industries across the globe. While this is

currently only a potential issue for the western rock lobster industry, fishing operations, processing and live export will almost certainly draw attention at some stage.

A study that identifies the risk areas in this regard and scopes the nature and viability of potential solutions along the supply chain would provide industry with a basis for pre-emptive action should this issue escalate for the industry.

This issue is considered to be of medium criticality and urgency and is principally the responsibility of WRL. Potential partners include UWA, Curtin and CSIRO.

3.4. Theme 4: Evidence-based policy, industry and market intelligence

3.4.1. Theme 4 Programme A: Resource access security

The following Figure 14 illustrates the determined priorities within Theme 4 Programme A.
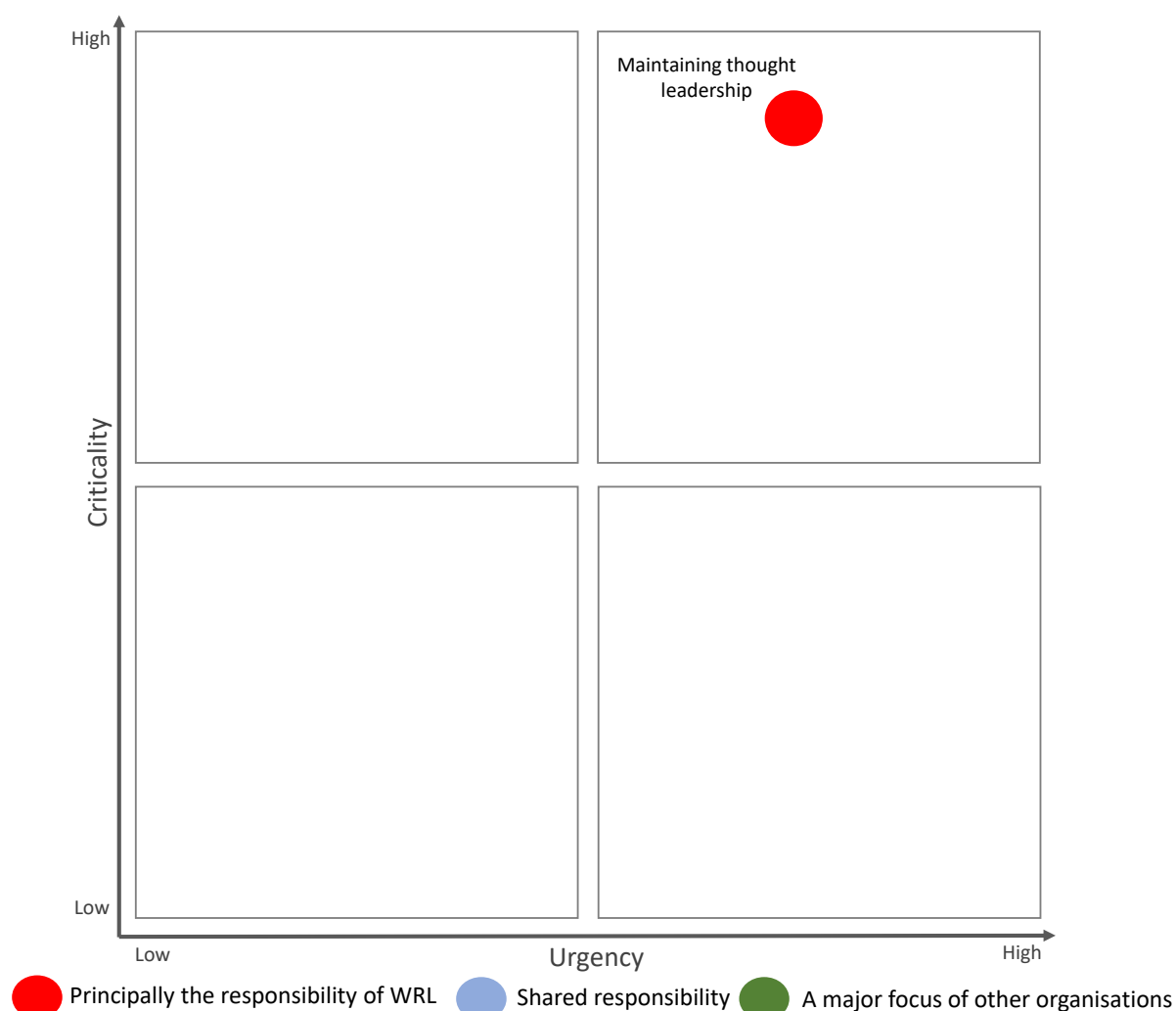
FIGURE 14 – PRIORITISATION OF RESEARCH AREAS IN THEME 4 PROGRAMME A: RESOURCE ACCESS SECURITY

The following Table 13 summarises the high criticality and high urgency research programs that are prioritised in the above Figure 14.

TABLE 13 - THEME 4 PROGRAMME A: RESOURCE ACCESS SECURITY RESEARCH AREAS

Research Areas

Maintaining thought leadership

The paramount advocacy issue for the western rock lobster industry is ensuring resource access security. The Western Rock Lobster Council has undertaken extensive work in this area, which has entrenched its position as the thought leader in Western Australia on the natural resource management, economic and legal case for secure commercial fishing rights. This complements other similar work undertaken by national and international commercial fishing organisations.

However, to mitigate the risks of required legislative amendments not being put into place, or further attempts by governments to appropriate commercial fishing rights, the western rock lobster industry must maintain its legitimacy as the intellectual authority on this issue.

Maintaining a watching brief on relevant development in commercial fishing rights across the globe and working with national bodies to coordinate policy development will serve to ensure that the industry is equipped to respond when and if necessary.

The encroachment by governments on commercial fishing rights is an ever-present threat. This issue is considered to be of high criticality and of medium to high urgency. It is the primary responsibility of WRL and an area that can draw on natural resource economics and legal expertise of UWA and Curtin, as well as the private sector.

3.4.2.   Theme 4 Programme B: Quota frameworks

The following Figure 15 illustrates the determined priorities within Theme 4 Programme B.

Legend:
- **Principally the responsibility of WRL** (red)
- **Shared responsibility** (blue)
- **A major focus of other organisations** (green)

Chart axes: Y-axis = Criticality (Low to High), X-axis = Urgency (Low to High)

Bubbles:
- Assessment of the case for split quotas
- Toward cross sector quota trading

FIGURE 15 – PRIORITISATION OF RESEARCH AREAS IN THEME 4 PROGRAMME B: ASSESSMENT OF THE CASE FOR SPLIT QUOTA

The following Table 14 summarises the high criticality and high urgency research programs that are prioritised in the above Figure 15.

TABLE 14 - THEME 4 PROGRAMME B: ASSESSMENT OF THE CASE FOR SPLIT QUOTA

Research Areas

Toward cross sector quota trading

It is widely understood that a system of integrated fisheries management based on set quota that is transparently grounded in sound scientific assessment of the resource, secure fishing rights and individual transferrable quota allocation is world-best-practice for managing most fisheries from an economic efficiency and resource sustainability perspective.

With an established and relatively reliable systems for resource assessment, a cross sectoral quota framework and individual transferrable quota system operating within the commercial quota, there is a basis for a cross sectoral market-based re-allocation trading system in western rock lobster. This would allow market forces to efficiently re-allocate quota between the commercial, recreational, charter and customary sectors.

The first stage in assessing this is a scoping study that explores the merits, viability and potentially operating models for cross sectoral market-based re-allocation as a basis for deep preliminary consultation with stakeholders in each sector of the western rock lobster fishery and DPIRD.

This issue is considered to be of medium criticality and urgency and a share responsibility with DPIRD and Recfishwest. Potential collaborators include UWA and private economics, legal and market advisory services.

Assessment of the case for split quotas

A significant benefit associated with quota-based systems for resource allocation is that through individual transferrable quota systems they facilitate the use of more efficient market mechanisms for allocation. However, somewhat perversely, they also provide governments with a mechanism to pursue policy objectives through arbitrary allocation of quota beyond just the commercial, recreational, customary and charter sectors.

An example of this is the current local market quota allocation under the commercial quota in the form of the Back-of-Boats (BOBs) program. In an extreme and undesirable circumstance this could evolve into specific local market quotas, or even quotas for particular product forms or overseas markets, albeit this would be a contravention of many of Australia's bilateral and multilateral trade agreements.

Understanding the commercial and license to operate implications of different forms of split-quota that governments may endeavour to impose on industry will be key to ensuring any changes in quota are of optimal benefit to the industry.

This issue is considered to be of medium criticality and urgency and a share responsibility with DPIRD. Potential collaborators include UWA and private economics, legal and market advisory services.

3.4.3.   Theme 4 Programme C: Capital access

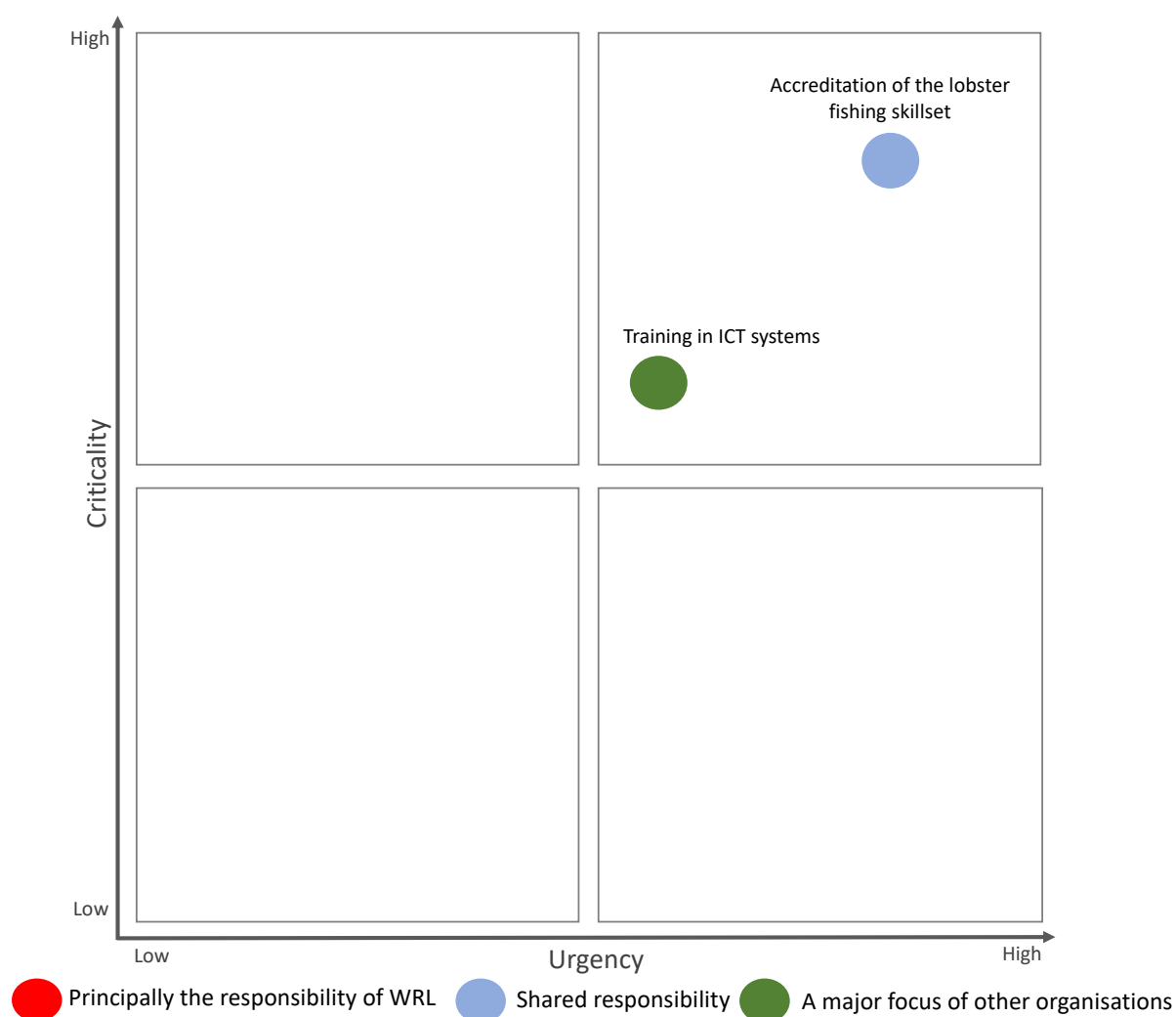The following Figure 16 illustrates the determined priorities within Theme 4 Programme C.
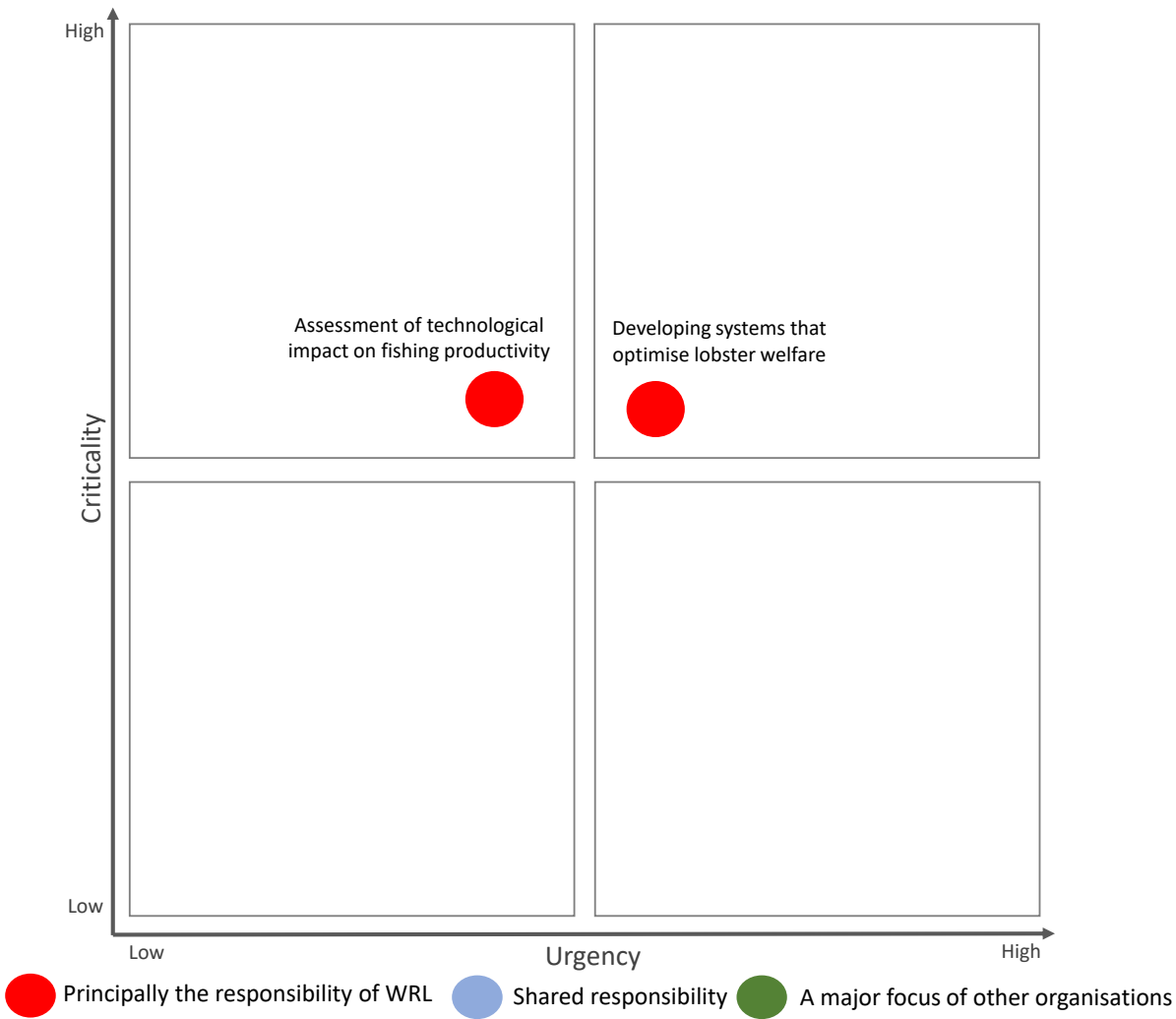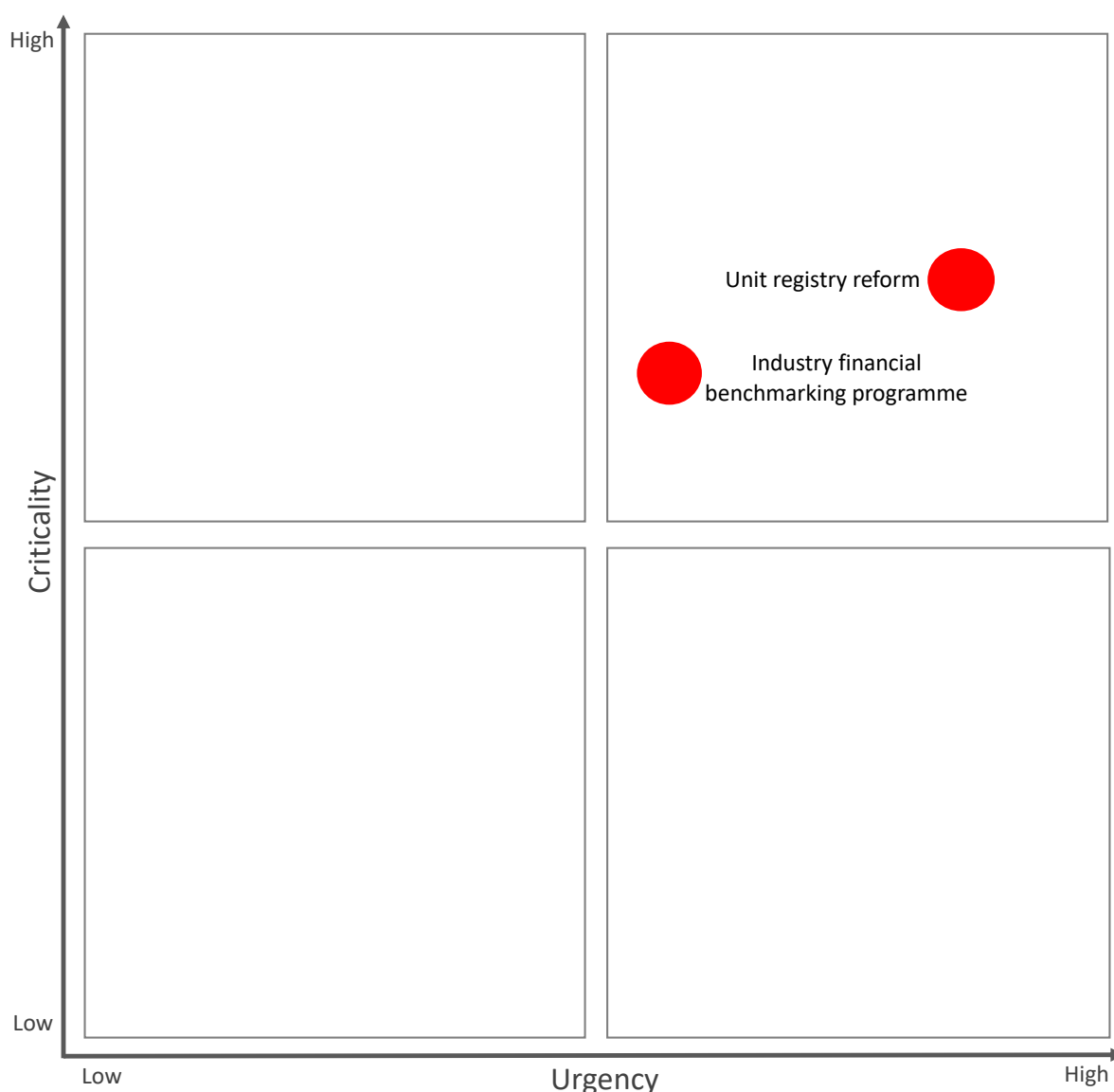
FIGURE 16 – PRIORITISATION OF RESEARCH AREAS IN THEME 4 PROGRAMME C: CAPITAL ACCESS

The following Table 15 summarises the high criticality and high urgency research programs that are prioritised in the above Figure 16, with other research priorities detailed in Appendix 1.

TABLE 15 - THEME 4 PROGRAMME C: CAPITAL ACCESS

<div align="center">Research Areas</div>

Industry financial benchmarking programme

The outcomes of the recent asset seizure has potentially undermined the bankability of the sector. A key input to the bankability of an industry is credible industry benchmark data that financiers can use to assess the bankability of actual businesses. Sectors that have previously had financing issues have overcome this problem through the development of reliable industry benchmarking data systems.

The first step in this is scoping the trialling of a data collection, aggregation, analysis and anonymised reporting of that analysis across key drivers of western rock lobster fishing business cash flow and profitability such as days fished, average catch, average labour costs, average fuel costs, average bait utilisation and costs, average repairs and maintenance cost, average capital intensity, etc. The

trial would be on a voluntary basis and undertaken in conjunction with the banking sector to design and test its utility.

This is primarily a WRL responsibility and is considered to be of medium to high criticality and urgency. Potential partner in this area are banks and finance advisory services.

Unit registry reform

The outcome of the recent asset seizure has undermined a perception held by industry and financiers that liens listed on the DPIRD unit register against quota were secure. A unit registry that does not provide for secure registration of liens over quota has limited if any use for financing purposes, other than to confirm quota ownership.

A feasibility study should be undertaken to determine the legal and practical issues that need to be overcome to implement a unit register that facilitates secure registration of liens by financiers hosted by either the Western Rock Lobster Council, DPIRD or another authorised third party service provider. This study should also give consideration to the scope of a prospective online quota trading platform that is the subject of Program A in Theme 3.

This issue is considered to be business critical but of low to medium urgency and secondary to resolving the quota trading platform issue. It is a shared responsibility between WRL and DPIRD, with potential partners including private sector legal advisory services.

3.4.4.   Theme 4 Programme D: Market access
The following Figure 17 illustrates the determined priorities within Theme 4 Programme D.

High

Market intelligence

Residue testing

Criticality

**Geographic traceability within
the fishery**

Low

Low   Urgency   High

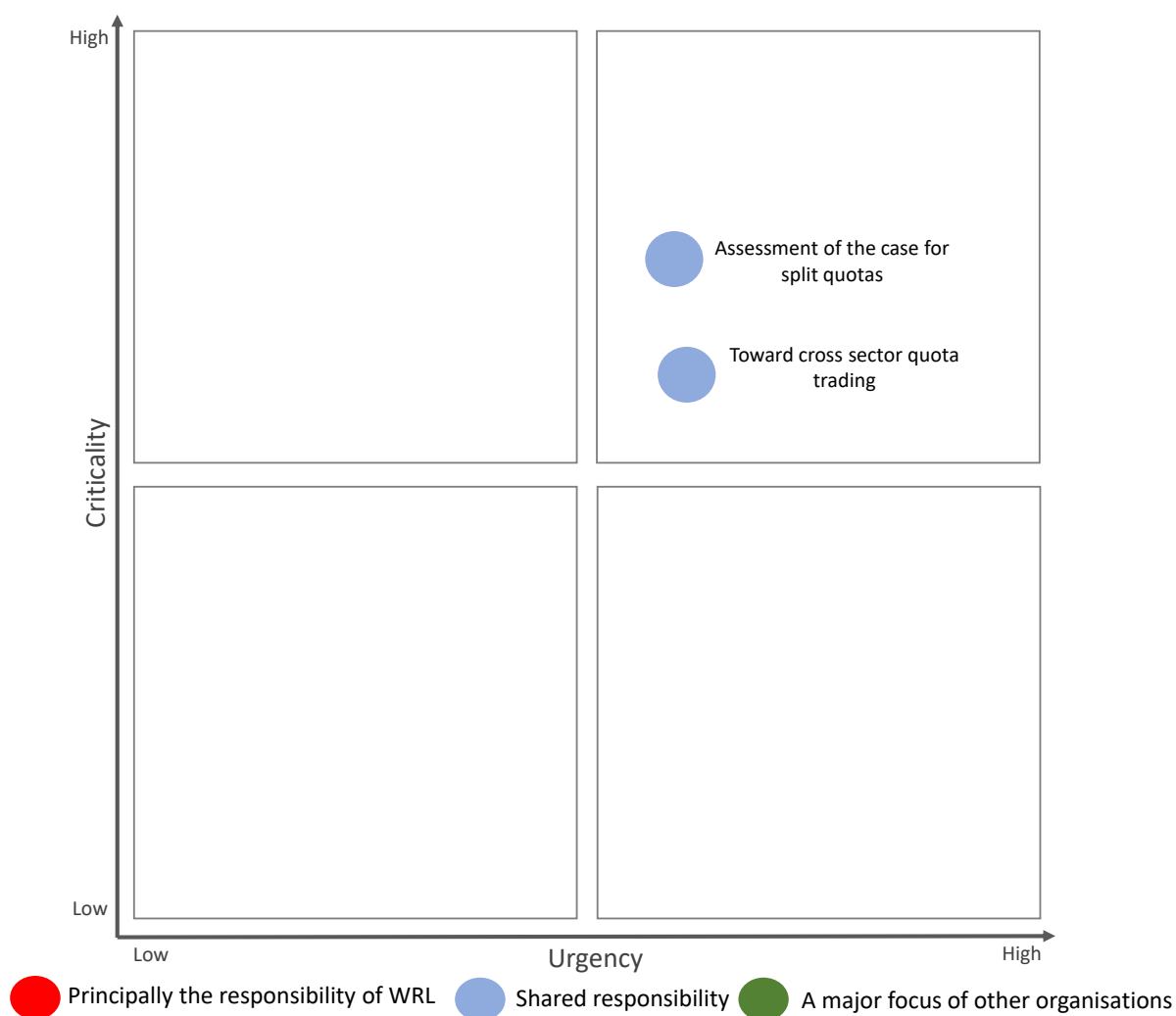● Principally the responsibility of WRL   ● Shared responsibility   ● A major focus of other organisations
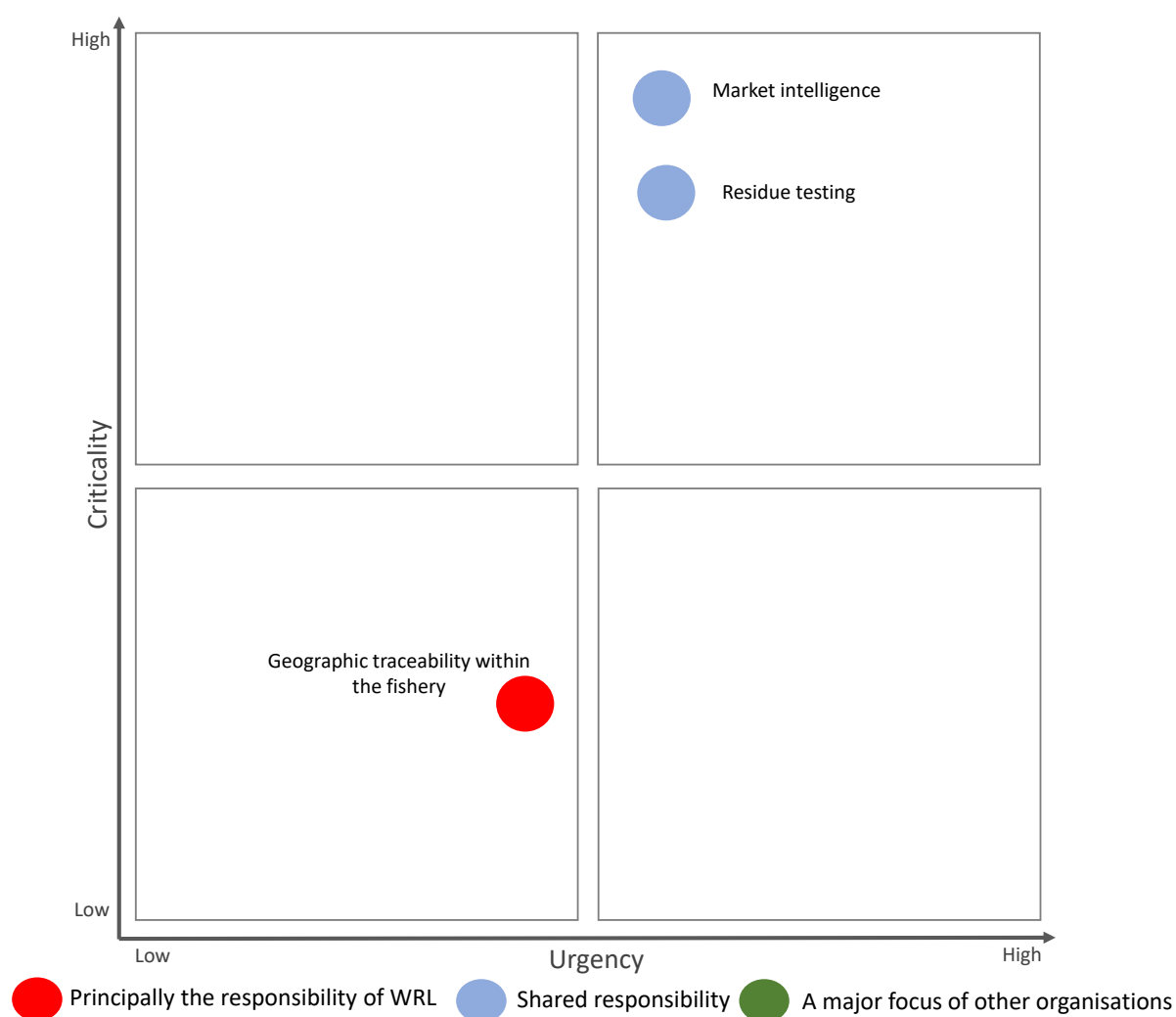
FIGURE 17 – PRIORITISATION OF RESEARCH AREAS IN THEME 4 PROGRAMME D: MARKET ACCESS

The following Table 16 summarises the high criticality and high urgency research programs that are prioritised in the above Figure 17, with other research priorities detailed in Appendix 1.

TABLE 16 - THEME 4 PROGRAMME D: MARKET ACCESS

Research Areas

Market intelligence

Deep knowledge of specific markets for western rock lobster is a source of competitive advantage for downstream processes, distributors and marketers of western rock lobster. However, from a whole of industry perspective, fishing businesses need to have some understanding of trends in key markets and industry peak bodies require knowledge of geopolitical trends that may lead to market disruption or opportunities to inform their advocacy.

This information can be attained most efficiently through clear arrangements with downstream businesses, where appropriate market intelligence is shared with the peak body and integrated with information in the public domain to keep industry informed and to inform advocacy.

This issue is considered of high criticality and urgency. It is a shared responsibility with the downstream sector and would be undertaken with private sector seafood market research organisations.

Residue testing

Potential presence of trace elements in exported western rock lobster was the cited reason for the most recent market disruption. The development of reliable and efficient pre-emptive testing for regulated trace elements by processors would substantially mitigate this risk in the future.

This issue can be progressed through research that seeks to develop reliable, rapid, cost-effective residue tests that do not impact product quality and can be effective deployed in the processing flow-of-product line.

This issue is considered of high criticality and urgency. It is a share responsibility with the downstream sector and SRL and would be undertaken with testing organisations

3.4.5. Theme 4 Programme E: Industry dynamics

The following Figure 18 illustrates the determined priorities within Theme 4 Programme E.
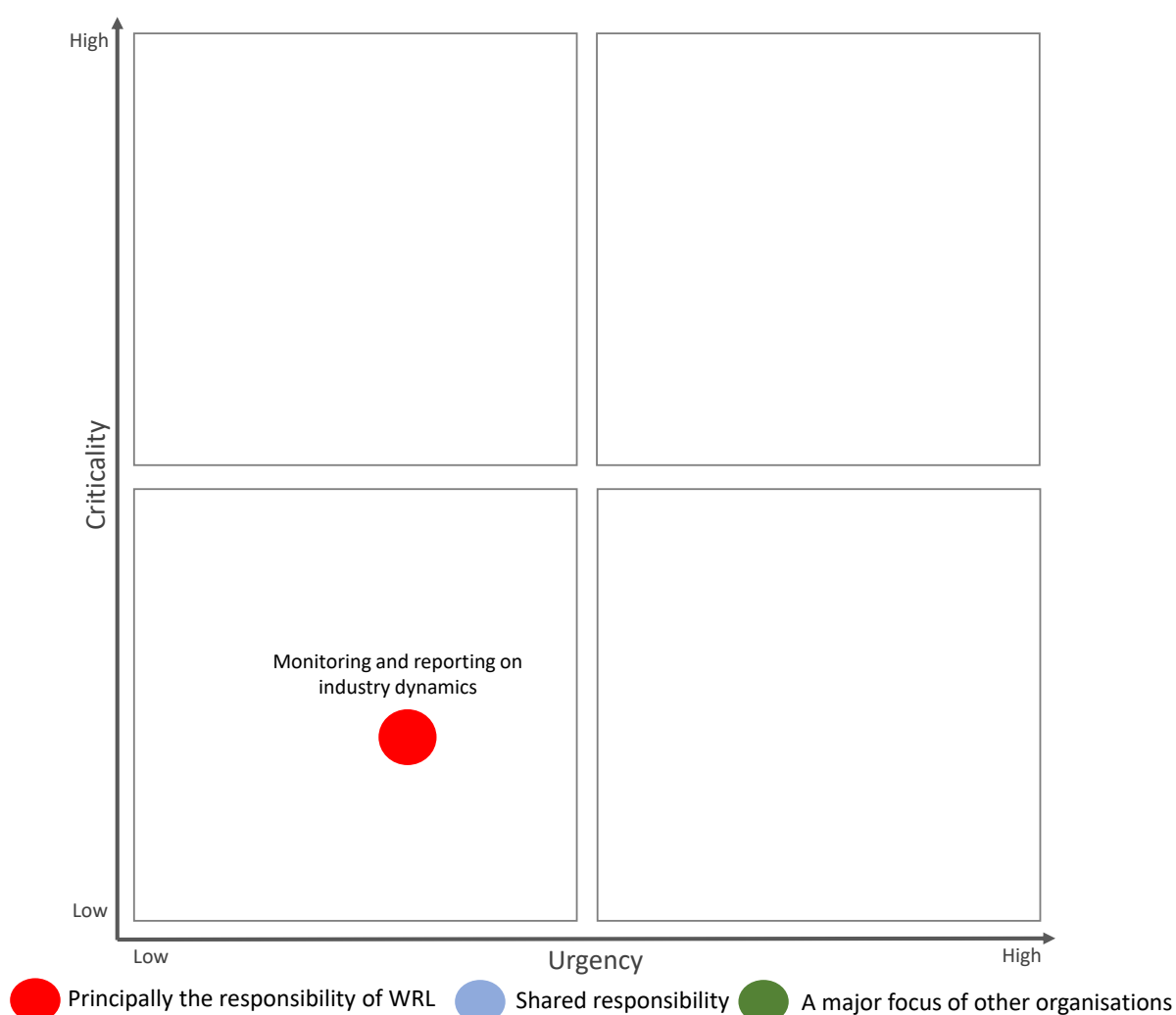
FIGURE 18 – PRIORITISATION OF RESEARCH AREAS IN THEME 4 PROGRAMME E: INDUSTRY DYNAMICS

The research priorities illustrated in Figure 18 are described in Appendix 1.

3.5. Theme 5: Enhancing social license to operate

3.5.1. Theme 5 Programme A: Ecological impacts of the western rock lobster industry

The following Figure 19 illustrates the determined priorities within Theme 5 Programme A.
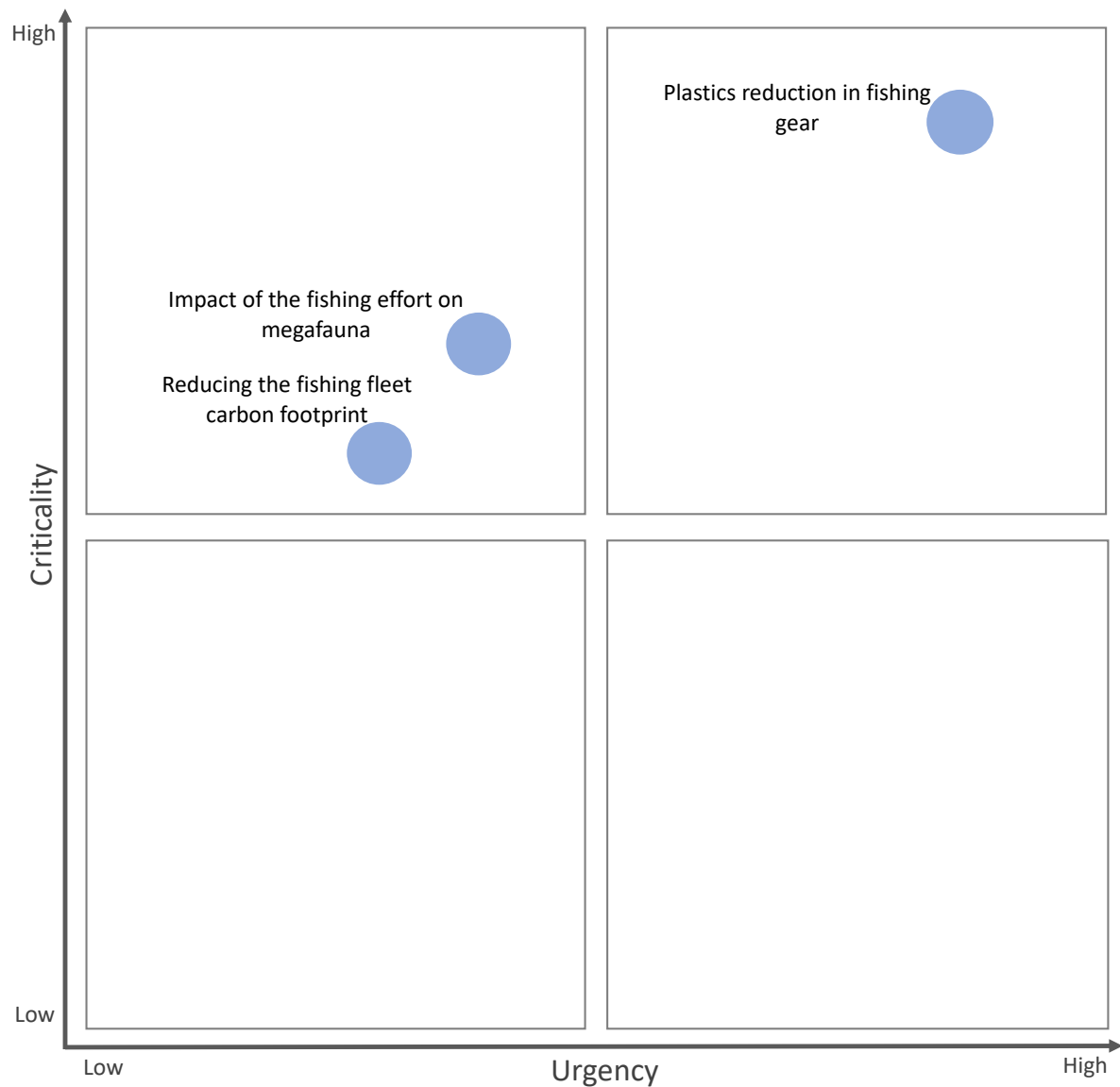
FIGURE 19 – PRIORITISATION OF RESEARCH AREAS IN THEME 5 PROGRAMME A: ECOLOGICAL IMPACTS OF THE WESTERN ROCK LOBSTER INDUSTRY

The following Table 17 summarises the high criticality and high urgency research programs that are prioritised in the above Figure 19, with other research priorities detailed in Appendix 1.

TABLE 17 - THEME 5 PROGRAMME A: ECOLOGICAL IMPACTS OF THE WESTERN ROCK LOBSTER FISHERY

Research Areas
Plastics reduction in fishing gear

Western rock lobster fishing gear typically incorporates a significant number of plastic components including bait traps, roles, floats and in some instances, the pots themselves.

In line with growing market and community concerns, innovation that presents competitive and practical alternatives to plastics in western rock lobster fishing gear will serve to alleviate market and community concerns in this regard.

Ocean plastics is a very topical issue. This is seen to be an issue of high criticality and urgency and a share responsibility with SRL. Potential partners include fishing equipment manufacturers.

3.5.2. Theme 5 Programme B: Local market access

The following Figure 20 illustrates the determined priorities within Theme 5 Programme B.

Understanding local market lobster demand and dynamics
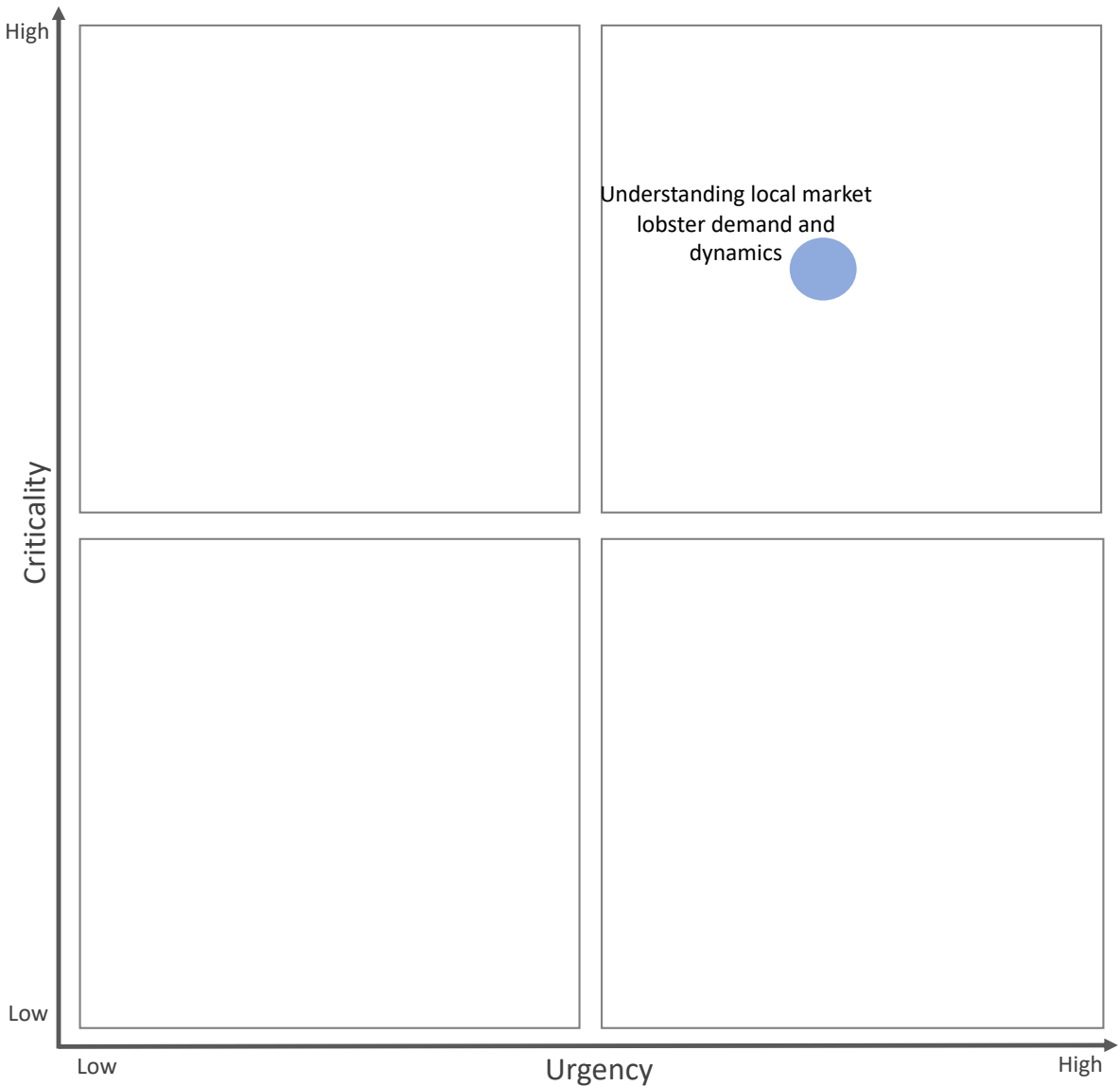
FIGURE 20 – PRIORITISATION OF RESEARCH AREAS IN THEME 5 PROGRAMME B: LOCAL MARKET ACCESS

The following Table 18 summarises the high criticality and high urgency research programs that are prioritised in the above Figure 20, with other research priorities detailed in Appendix 1.

TABLE 18 - THEME 5 PROGRAMME B: LOCAL MARKET ACCESS

Research Areas

Understanding local market lobster demand and dynamics

An absence of accessible and affordable supply of western rock lobster in local markets has been cited as a social-license-to-operate challenge for the western rock lobster and has been the subject of Western Australian Government policy intervention.

To respond effectively to this challenge, industry must understand how 'real' the issue is and its true nature. A study that delivers evidence-based analysis as to issues such as trends in local demand throughout the year, identification and segmentation of the end customer, preferred purchase methods and practical issues associated with different purchase methods (e.g. BOBs), extent of product value appropriation by restaurants (i.e. margin) and use and informal distribution of the recreational catch, will assist industry in understanding the precise nature of the issue and how best to respond to it to reinforce industry's license to operate.

This issue is primarily a WRL concern and is considered to be of medium to high criticality and urgency. Potential partners are UWA, Curtin and private sector market research firms.

3.5.3. Theme 5 Programme C: Effective community engagement

The following Figure 21 illustrates the determined priorities within Theme 5 Programme C.
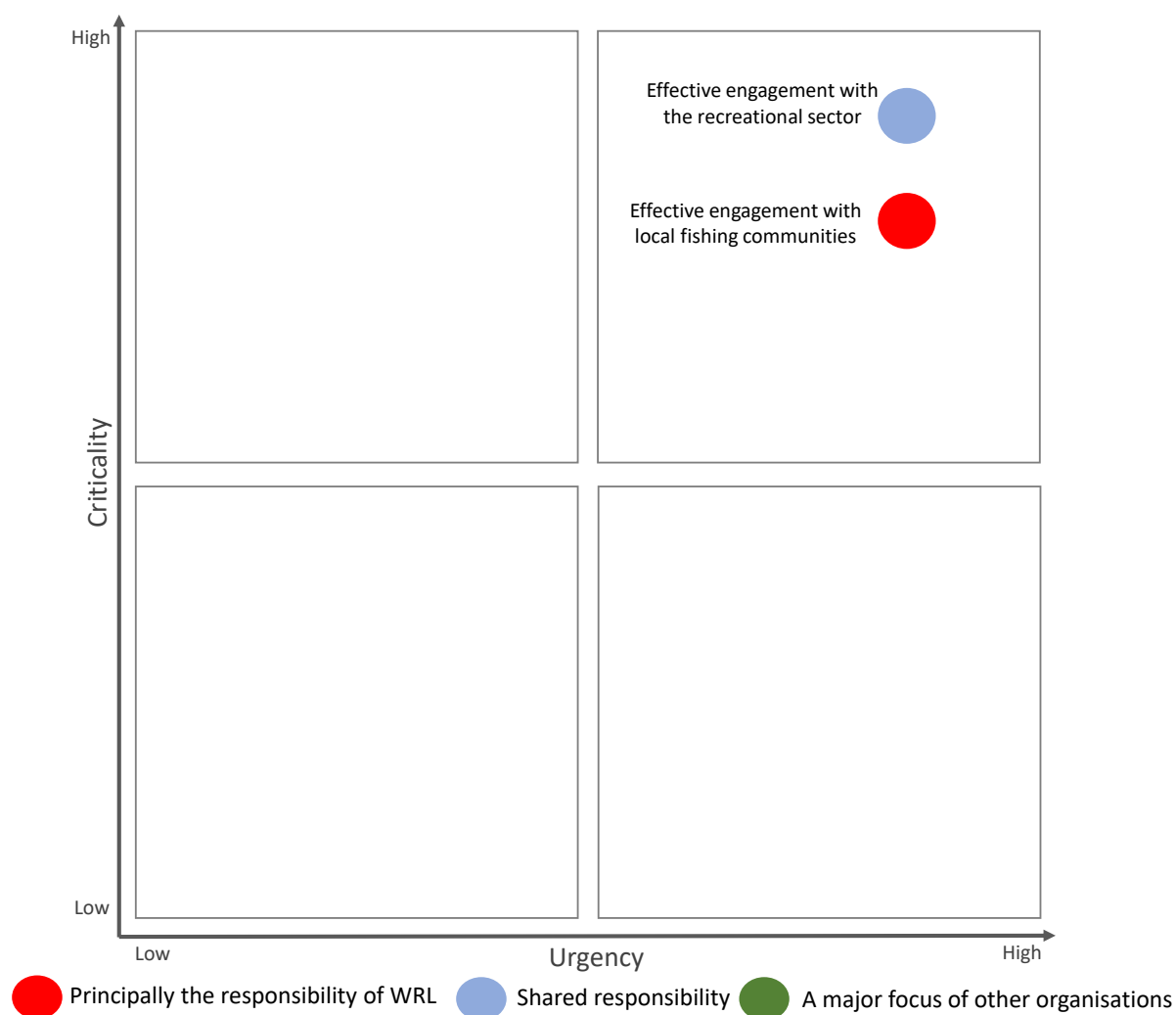
FIGURE 21 – PRIORITISATION OF RESEARCH AREAS IN THEME 5 PROGRAMME C: EFFECTIVE COMMUNITY ENGAGEMENT

The following Table 19 summarises the high criticality and high urgency research programs that are prioritised in the above Figure 21.

TABLE 19 - THEME 5 PROGRAMME C: EFFECTIVE COMMUNITY ENGAGEMENT

Research Areas

Effective engagement with the recreational sector

As the industry's main partner in the shared western rock lobster shared resource, it is in industry's interests to ensure that it has a functional and harmonious relationship with the recreational sector.

Research that revolves around collaboration with the recreational sector and delivers mutual benefits is beneficial in this regard.

This is a shared responsibility with Recfishwest and is considered an issue of high criticality and urgency.

Effective engagement with local fishing communities

Historically, the economies of many coastal towns in Western Australia have revolved around the western rock lobster industry. A reduction in the operational footprint of the industry that occurred when the industry shifted to quota combined with economic diversification of the larger coastal settlements means that in many instances the western rock lobster industry isn't as critical to the economic and social fabric of those towns as it once was.

However, support for these industries from these coastal communities is vital for the industries social-license-to operate.

Research that informs initiatives that can continue to underpin community support in this regard will ensure the industry is able to operate.

This is primarily a WRL responsibility and of high criticality and urgency. Potential partners include UWA, Curtin and private sector community engagement advisory firms.

3.6. Theme 6: Ensuring industry adoption of research outcomes and communicating to stakeholders

3.6.1. Programme A: Industry engagement

Keeping the WRL membership abreast of the investments and activities of the WRL Research Network is critical in ensuring ongoing support for its efforts and interest in research outcomes that is necessary as a precursor to adoption of those outcomes. However, most importantly, frequent, genuine and constructive engagement with industry across the research portfolio helps to ensure that research investments and project outcomes remain acutely targeted on the needs of industry.

Bi-annual research newsletter

To ensure that all WRL members and other stakeholders have immediate access to information on specific investments by the WRL Research Network, status of projects and outcomes, the WRL Research Network will email members and other stakeholders an bi-annual online publication providing this information.

Annual Management Meeting research workshop

In order to provide an opportunity for deeper engagement with the activities of the WRL Research Network, each year immediately following each of the Annual Management Meetings, a full day research workshop will be held of members and other stakeholders who wish to participate. These will be interactive sessions that showcase specific research projects and planned projects providing members and other stakeholders with an opportunity to provide immediate impact and if they wish, participate in specific projects going forward.

3.6.2. Programme B: Stakeholder communications

The WRL Research Network and its outputs will also perform a key role in the broader public face of the western rock lobster industry.

Research investment awareness

A coordinated enhanced investment in research and development by the western rock lobster industry has value from a social license to operate perspective. Generally, speaking research, particularly that which has implications for natural resources and sustainable

development, is seen in a positive light by both governments and the wider community. Promoting this will serve to enhance the industry's license to operate and elevate WRL's credentials as an important institution from a research, sustainability and economic development perspective.

To this end, WRL will ensure that establishment of the WRL Network is well communicated and overtime, key stakeholders, governments and the community are aware of its investments and outcomes. The WRL Network will be a standalone reporting item in WRL's Annual Report and other relevant communications materials.

Informing advocacy

The WRL Network will also perform a role underpinning WRL advocacy on specific issues where appropriate. This will not only result in more compelling advocacy cases and more effective advocacy prosecution but will also elevate the reputation of the industry and provide profile for the WRL Research Network.

3.6.3. Programme C: Translation and adoption

Clear knowledge outcome definitions

The WRL Research Network is focused on producing knowledge, decision tools and technologies that can be used by industry and other end users to ensure continuity of the industry and enhancement of its productivity and profitability.

To optimise the likelihood of practical and usable outcomes, all research projects undertaken by the WRL Research Network will have a requirement to demonstrate deep and genuine engagement with the targeted end user and to ensure that the nature and form of output is defined and continually reviewed through the implementation and conduct of the project.

Deliberate and targeted translation

The outcomes of WRL Research Network projects will be promoted and delivered directly to their intended end-user, providing adoption and usage support to those end users.

Research outcomes adoption measurement

The WRL Research Network will establish a framework for recording and maintain a database of metrics that are relevant to measuring the extent to which its outcomes have been adopted by industry and other stakeholders and report on these metrics on an annual basis through the WRL annual report.

This data will both ensure accountability and provide a basis for identifying issues to be addressed through continuous improvement.

4. Governance and Operations of the Western Rock Lobster Research Network

The Consultation Working Draft identified five separate structural options for delivering on the Research Priorities Framework:

1. Continuation of the current research management arrangement utilised by WRL
2. An enhanced research governance and management function within WRL
3. Outsourcing the research function to the Western Australian Marine Science Institution
4. Establishing a stand-alone western rock lobster research subsidiary
5. Progressing to a larger stand-alone Western Australian Fishing and Aquaculture Research Institute under which western rock lobster research would form part of a broader Western Australian seafood industry, recreational and customary research portfolio.

The overwhelming preference among consulted stakeholders for the Research Priorities Framework to be implemented under an enhanced research governance and management function within WRL, with potential future progression to a Western Australian Fishing and Aquaculture Research Institute.

The focus of this governance and operating model is exclusively on the establishment and operations of the WRL Research Network in accordance with the preferred model.

4.1. Guiding principles

The governance and operations of the WRL Research Network will be guided by the principles outlined in the following Table 20.

TABLE 20 – GUIDING PRINCIPLES FOR THE WRL RESEARCH NETWORK

	Principle	Description
1.	Genuine end-user engagement	To ensure that the WRL Research Network remains end-user focused, there will continuous and deep engagement with fishers, processors and other key stakeholders in research project design, implementation and outcome translation.
2.	Primacy of the Research Priorities Plan	The Research Priorities Plan will be the primary document that guides research investments. Developed in deep consultation with end-users and other stakeholders its sets out agreed priorities. Deviation from these priorities should only occur in the case of unforeseen critical issue that requires urgent research attention and only through due process.
3.	Professional research project management	The processes associated with designing research projects, assembling research teams, applying for research grants and other sources of funding, managing the implementation of research projects and translating their outcomes should be undertaken by a professional research manager.
4.	Efficient research investment	Because research resources are scarce, all effort should be made to minimise duplication of research efforts, optimisation of strategic collaborations and minimisation of administrative overheads.

5.	Building local capability and accessing worlds-best capabilities	While a specific objective of the WRL Network will be to continue to develop Western Australia's world-class lobster research capability, the WRL Network will ensure that it brings the world's best research capabilities to bear on industry opportunities and challenges.
6.	Translated outcomes	The WRL Research Network will have a significant focus on ensuring the outcomes of all of its research are effectively communicated and useable by end-users.

4.2. Governance framework

The purpose of the governance framework that applies to the WRL Research Network is to ensure the integrity of the decision-making process such that investments made under the WRL Research Network efficiently produce optimal outcomes for end-users.

Operating internally within WRL, the WRL Research Network governance framework is comprised of the following key components:

- WRL Research Priorities Plan
- WRL Board
- WRL Research Advisory Group
- WRL Executive

The WRL Research Network governance and operating framework is illustrated in the following Figure 22 and detailed in the subsequent subsections.
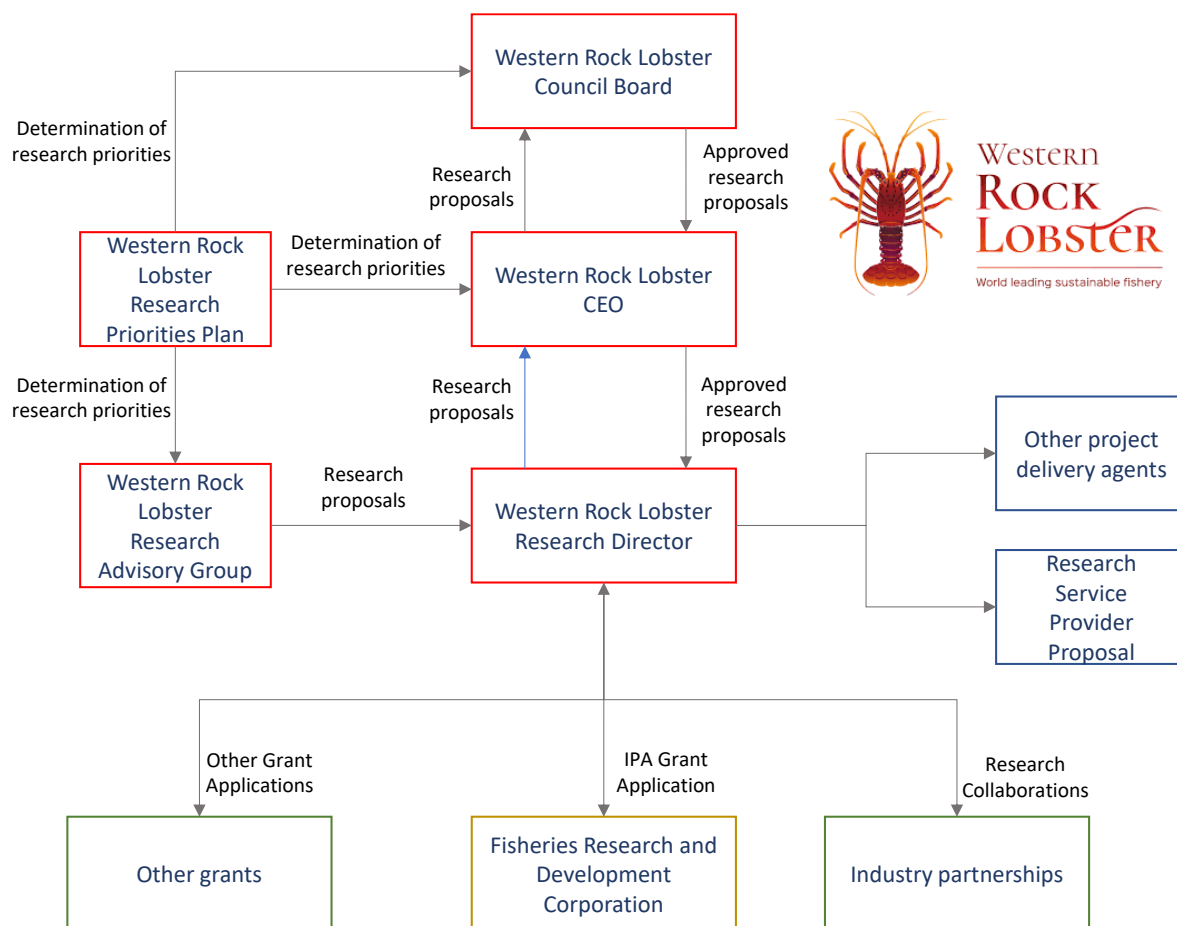
FIGURE 22 – WRL RESEARCH NETWORK GOVERNANCE AND OPERATIONS FRAMEWORK

4.2.1. WRL Research Priorities Plan

Once finalised and endorsed by the WRL membership and board, the Research Priorities Plan set out in Section 2 and detailed in Section 3 will become the WRL Research Priorities Plan. This document will form a key element of the WRL Research Network governance framework.

Sets the research program

The Board of WRL will pass a resolution that means that subject to period review and emergency responses (see below), the Board may not approve any research project that is not within the scope of the research areas identified in the Research Priorities Plan and must allocate research investments in accordance with the priorities set out in the Research Priorities Plan.

Periodic review

Changes in the natural resource, regulatory environment, market and industry dynamics over time will mean that research priorities may change and new research areas may emerge. To address this, the Research Priorities Plan will be the subject of a prescribed periodic review process.

The Research Priorities Plan will be the subject of a topical review by the Board every two years. This topical review will involve no more than the Board, working with the CEO and Research

Director, reflecting on the research areas and priorities of the plan to ensure that they remain comfortable that priorities and areas remain appropriate.

Every five years, the Research Priorities Plan will be subject to a major independent review that will include extensive consultation with membership of WRL, processors, scientific sector and regulators similar to that used to develop the inaugural Research Priorities Plan.

Emergency research responses

From time-to-time ecological, natural resource, market, policy and other issues will arise that require an urgent research response. At the time these issues arise they may not be within the scope of a priorities research area or even with the scope of the Research Priorities Plan.

To address this issue the WRL Board will have the flexibility to allocate research resources to such 'emergencies' when they arise. In doing so, the WRL Board must be able to convince itself that the emergency is such that it justifies deviating from the current Research Priorities Plan and post decision, explain the rationale for the deviation to the WRL membership.

4.2.2.   WRL Board

As the ultimate decision-making body of WRL, the role of the WRL Board in the governance of the WRL Research Network is to, within the scope prescribed by the WRL Research Priorities Plan and related processes set out in Section 4.2.1 above, approve or reject research proposals presented to it by the WRL executive.

In reviewing proposals, the WRL Board may ask the WRL executive to revise certain aspects of proposals and in approving or rejecting a proposal it must convince itself that its decision is consistent with the requirements under Section 4.2.1 above.

4.2.3.   WRL Research Advisory Group

To support advice provided by the WRL executive to the WRL Board with respect to research project proposals, a WRL Research Advisory Group will be established.

Terms of Reference

The Terms of Reference for the Research Advisory Group are, with absolute reference to the WRL Research Priorities Plan, work with the WRL Research Director to:

1. Identify specific research project opportunities;
2. Advise on the assembly of research project teams;
3. Advise of the design of research projects; and
4. Review and advise on research project outcomes.

Composition and operations

The Research Advisory Group will be comprised of representation end-users and other key stakeholders as well as appropriate scientific expertise and will include:

- WRL Chief Executive Officer (Chair)
- WRL Research Director (ex-officio)
- Three representatives of fishers
- Two representatives of processors and seafood marketing
- One representative from DPIRD
- One representative from FRDC
- Two representatives from the university sector (rotating periodically)

The WRL Research Advisory Group will meet at least quarterly.

4.2.4. WRL Executive

Western Rock Lobster Research Network Director

A new position (see Section 4.3.1 below), the WRL Research Director will have primary responsibility for implementation and management of the WRL Research Network.

Western Rock Lobster Chief Executive Director

The WRL Chief Executive Officer is responsible for chairing the WRL Research Advisory Group and is the main interface between the WRL Research Network and WRL Board.

4.3. Operating plan

4.3.1. Executive function: WRL Research Network Director

Role description

To give effect to the WRL Research Network a new position of Research Network Director will be created within WRL. With primary responsibility for implementation and ongoing management of the WRL Research Network, the key functions of the WRL Research Director will be:

- Working with the WRL Research Advisory Group, design research projects that address the priorities set out in the Research Priorities Plan
- Working with other stakeholders to ensure WRL has significant input into research projects for which there are shared interests or the research subject matter is a major focus of another organisation
- Assemble research project teams on the advice of the WRL Research Advisory Group
- Work with the WRL CEO to prepare research project proposals for WRL Board Review and approval
- Engage with the FRDC and other external sources of research funding to optimise leverage
- Project manage approved and funded research projects
- Report on research project progress to the WRL Research Advisory Group, CEO and Board, as well as to external stakeholders as required
- Ensure that research project outcomes are communicated and translated effectively to WRL members.

Capability requirements

The WRL Research Director should be an experienced research project manager.

Critical criteria include:

- At least a rudimentary understanding of fisheries issues
- Understanding and appreciation of strategic approaches to industry-oriented research
- Experience in research project planning and management
- Successful track record in scientific (fundamental and applied) grant applications
- Demonstrated ability to facilitate and lead research where there are shared interests across multiple sectors and organisations

- Experience in working with multi-disciplinary and industry-oriented boards and advisory groups
- Experience in translating research outcomes

Other desirable criteria include:

- Existing networks with relevant research and research funding organisations
- Fisheries or other marine science expertise

Key Performance Indicators (KPIs) should include:

- Giving effect to the research priorities that are principally the responsibility of WRL
- Putting together and effectively working in cross-organisation and cross-sector teams to give effect to research priorities that are shared responsibilities and to ensure there is adequate WRL input to research priorities that are a major focus of other organisations
- Achieving adequate leverage from the research funds available through the WRL IPA (see Section 4.3.2)

4.3.2. Budget

Operating budget

The following Table 20, summarises the proposed operating budget for the WRL Research Network. The vast majority of the administrative component of the budget in the early years is the salary cost of the WRL Research Network Director. In the early years, the WRL Research Network will share the internal executive officer and communications capabilities of WRL. However, it is anticipated that as the research portfolio grows, the WRL Research Network will require its own capacity in this regard, commencing 2024-25/2025-26.

TABLE 21 – WRL RESEARCH NETWORK OPERATING BUDGET

	2022-23	2023-24	2024-25	2025-26	2026-27	Five-year Total
Governance						
Advisory Group operating expenses and sitting fees	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 50,000
Subtotal - Governance	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 50,000
Operations						
WRL Research Network Director salary and oncosts	$ 190,000	$ 190,000	$ 190,000	$ 190,000	$ 190,000	$ 950,000
WRL Research Network Executive Officer[2]	$ -	$ -	$ 100,000	$ 100,000	$ 100,000	$ 300,000
WRL Research Network Communications Officer[3]	$ -	$ -	$ -	$ 100,000	$ 100,000	$ 200,000
Data and research management IT	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 50,000
Travel budget	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 50,000
Reporting and communications budget	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 50,000
Subtotal - Operations	$ 220,000	$ 220,000	$ 320,000	$ 420,000	$ 420,000	$ 1,600,000
Total Administration Budget	$ 230,000	$ 230,000	$ 330,000	$ 430,000	$ 430,000	$ 1,650,000

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[2] Executive officer functions will be shared with WRL corporate in early years

[3] Communications officer functions will be shared with WRL corporate in early years

Research budget

While the industry adjusts to the market disruption caused by the actions taken by the PRC, it is anticipated that the three-year rolling average of industry GVP will decline over the coming years. This will, in turn, result in a declining amount allocated to the WRL IPA. However, by pursuing a more strategic approach to research investment in accordance with the Research Priorities Plan (see Section 2) and leverage additional resources such as those identified in the following subsection, the WRL Research Network will substantially increase the research resources available to it, potentially as high as 4:1. This will not only better resource the projects addressing WRL's research priorities, but will also decrease the WRL Research Network administrative costs as a portion of the research investment.

This is summarised in the following Table 22.

TABLE 22 – WRL RESEARCH NETWORK RESEARCH BUDGET

	2022-23	2023-24	2024-25	2025-26	2026-27	Five year Total
Estimated FRDC hypothecation to the WRL IPA[4]	$ 750,907	$ 621,669	$ 604,167	$ 625,000	$ 625,000	$ 3,226,743
Leverage 1:1	$1,501,814	$1,243,338	$1,208,334	$1,250,000	$1,250,000	$ 6,453,486
Leverage 2:1	$2,252,721	$1,865,007	$1,812,501	$1,875,000	$1,875,000	$ 9,680,229
Leverage 3:1	$3,003,628	$2,486,676	$2,416,668	$2,500,000	$2,500,000	$ 12,906,972
Leverage 4:1	$3,754,535	$3,108,345	$3,020,835	$3,125,000	$3,125,000	$ 16,133,715
Administration costs (1:1)	31%	37%	55%	69%	69%	26%
Administration costs (2:1)	10%	12%	18%	23%	23%	17%
Administration costs (3:1)	8%	9%	14%	17%	17%	13%
Administration costs (4:1)	6%	7%	11%	14%	14%	10%

Resourcing strategy

It is the intent that the WRL Research Network Director salary will be at least part funded from the WRL IPA. The balance of the annual IPA funds will be invested in research in accordance with the processes discussed in Section 4.2 and 4.3, with identifying opportunities to leverage those funds against other relevant external sources a key component of the development of all projects.

The following Table 23 summarises some potential other sources of research funding that could be used to leverage the WRL IPA resources.

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[4] Estimated to decline over the short-to-medium term in accordance with industry GVP forecasts

TABLE 23 – EXTERNAL GRANT SOURCES

Grant Name	Organisation	Funding Purpose
Science and Research Fund	Marine Stewardship Council	Grants for research projects that help fisheries to meet and maintain sustainability best practice. Up to £50,000.
Recertification Assistance Fund	Marine Stewardship Council	Assists MSC certified fisheries with the cost of Conformity Assessment Body fees for the second or subsequent recertification audit.
AMFA Research Program	Australian Fisheries Management Authority (AMFA)	Funding for research projects aligned with AMFA's annual research plan.
Recreational Fishing Initiatives Fund	Recfishwest	Funding for research projects aimed at enhancing recreational fishing in WA.
Regional Economic Development (RED) Grants	Department of Primary Industries and Regional Development (DPIRD)	Investment into community-driven projects that support efforts to create long-term economic growth and job sustainability in WA's regions.
Value Add Investment Grants	Department of Primary Industries and Regional Development (DPIRD)	Funding for WA businesses to boost local food and beverage manufacturing and value adding.
International Competitiveness Co-Investment Fund	Department of Primary Industries and Regional Development (DPIRD)	$3 million committed across three funding rounds between 2020-2022. Support to businesses to rebuilt existing Asian market business relationships disrupted by COVID-19 and to develop and implement strategies to capture export market opportunities, to ultimately benefit regional WA.
Agrifood and Beverage Voucher Program	Department of Primary Industries and Regional Development (DPIRD)	Support for WA agrifood and beverage manufacturers to engage business consultants or technical experts.
Value Add Agribusiness Investment Attraction Fund	Department of Primary Industries and Regional Development (DPIRD)	The fund aims to support businesses to invest in new projects or expansion opportunities in WA, that will build competitiveness, adopt innovative technologies and grow their operations.

Grant Name	Organisation	Funding Purpose
Export Market Development Grants (EMDG)	AUSTRADE	Grants to help Australian small and medium enterprises grow their exports in international markets.
Cooperative Research Centre (CRC) Grants	Australian Department of Industry, Science and Technology	Provide funding for medium to long-term, industry-led research collaborations, for up to 10 years.
Cooperative Research Centre (CRC) Projects Grants	Australian Department of Industry, Science and Technology	Provide funding support for short term, industry-led collaborative research, for up to 3 years.
The Linkage Program	Australian Research Council (ARC)	Promotes national and international research partnerships between researchers and business, industry, community organisations and other publicly funded research agencies.
Industrial Transformation Research Program (ITRP)	Australian Research Council (ARC)	Seeks to engage Australia's best researchers in issues facing the new industrial economies and training the future workforce. Food and agribusiness is one of the current industrial transformation priorities and the program. The program funds Research Hubs and Training Centres.

Appendix 1 – Additional Research Priorities

This appendix lists the descriptions of all of the additional research priorities that have been deemed not to be high criticality and high urgency by the WRL industry. They are listed by theme, program and priority level. The corresponding, coloured circles, as shown below indicate who is primarily responsible for undertaking this research.

FIGURE 23 – RESPONSIBILITY OF RESEARCH PRIORITIES

● Principally the responsibility of WRL　　● Shared responsibility　　● A major focus of other organisations

Theme 1: Program A: Western rock lobster lifecycle and biology

The following Table 24 summarises the research programmes that are not high criticality and high urgency in **Error! Reference source not found.**.

TABLE 24 - THEME 1 PROGRAM A: WESTERN ROCK LOBSTER LIFECYCLE AND BIOLOGY

Research Areas

Low Criticality, Low Urgency

Understanding the connection between the lifecycle of northern and southern western rock lobster populations

The limited genetic variation between cohorts of western rock lobster indicates that the western rock lobster population is panmictic. Broadly, this has been explained by larval mixing in the open ocean. It also indicates that differences in recruitment and growth rate across zones are caused by ecological factors, rather than genetics. However, a more scientific based understanding of the lifecycle of western rock lobster within and across difference zones may inform fishing tactics and potential future stock enhancement initiatives. For example, why specifically has abundance declined in the northern areas of the fishery, while most other regions have seen increases in abundance.

While research in this area can inform tactical fishing and quota investment, as well as resource management decisions, and therefore should also be of interest to DPIRD, it is not considered as business critical or urgent as the previous two research areas under this program 1. Potential partners in this research area include UWA and CSIRO.

Do puerulus settle in deep water?

A potential explanation for the anomalies in puerulus settlement in 2008-09 and other years is that some puerulus may be settling in deeper water rather than onshore reefs. Historically, this theory has been discounted. However, an evidence-based understanding of possibility of deep-water settlement of puerulus, survival of puerulus that may settle in deep water and how many are recruited into the fishery would provide the basis for a broader understanding of ecological impacts on western rock lobster lifecycle, ultimately better informing stock assessment models.

In light of growing concerns among fishers as to the accuracy of predictive stock modelling, this research area is considered a critical and urgent area of research that should also be a priority of DPIRD. Other potential partners in this research area include UWA and CSIRO.

Causes and mitigation of cotton-tail in the lobster catch

Each year a relatively small portion of the western rock lobster commercial catch presents with a condition known as 'cotton tail', whereby the adult lobster's flesh (when viewed through the membrane under the tail) has 'cooked' appearance. Lobsters presenting with cottontail are not marketable and are deducted from the fisher's payment by processors. Causes of cottontail are not known and methods for mitigating cottontail through processes such as on-board returns or potential culling from stock have not been explored or assessed. Reducing the instance of cottontail will increase the profitability of fishers.

This principal stakeholder affected by this issue are western rock lobster fishers. However, because cotton-tail effects only a very small portion of the catch, it is not considered to be an issue of high criticality or urgency. If the prevalence of cotton-tail was to increase dramatically, this issue should be prioritised accordingly.

Theme 1 Program B: Western rock lobster habitat and ecology

The following Table 25 summarises the research programmes that are not high criticality and high urgency in Figure 6.

TABLE 25 - THEME 1 PROGRAM B: WESTERN ROCK LOBSTER HABITAT AND ECOLOGY

Research Areas

High Criticality, Low Urgency

Enhanced prediction of currents that impact on the western rock lobster ecology

The strength of the Leeuwin Current and its eddies are major determinants of the western rock lobster lifecycle and the ecology that supports it.

Enhanced ability to predict changes in current strength, location and strength of eddies will be better inform stock prediction models and tactical fishing decisions. This issue is considered to be of moderate criticality, but high urgency. It is also a major focus of other organisations such as UWA, CSIRO, Western Australian Marine Science Institution (WAMSI) and the Integrated Marine Observing System (IMOS).

Being able to better predict changes in ocean currents will better inform stock prediction models and tactical fishing decisions. However, while the outcomes of research in this area of obvious interest to the western rock lobster industry, this issue is the primary focus of other research organisations. CSIRO, UWA, WAMSI and IMOS undertake significant research in this area.

Enhanced prediction of warm water events that impact on the western rock Lobster ecology

Warm water events associated with El Nino Southern Oscillation and the Leeuwin Current, such as the 2011 event, have a dramatic impact on the western rock lobster lifecycle and the ecology that supports western rock lobster stocks. Further, as a result of global climate change, the incidence of warm water events along the Western Australian coastline is expected to increase.

Being able to predict future occurrences of warm water events will better inform stock prediction models and fishing business investment decisions. However, while the outcomes of research in this area of obvious interest to the western rock lobster industry, this issue is the primary focus of other research organisations and until there is accurate long-term forecasting

the knowledge has limited practical use. The CSIRO and UWA undertake significant research in this area.

Low Criticality, Low Urgency

River mouths and productivity in the western rock lobster fishery

As with many fisheries, the delivery of nutrient to inshore areas from inland freshwater river systems performs a fundamental role in fishery productivity, primarily by providing suitable nutrient for fish or their prey at earlier phases of their lifecycle. As with much of Australia, the nutrient, as well as toxin loading in river systems ingress has increased over the past 200 years as a result of agriculture and other anthropogenic activity.

Key river mouth systems for the western rock lobster fishery are the Irwin and Moore River mouths. However, with puerulus settling in November and the majority of freshwater ingress occurring during the winter months, there is a mismatch. As such, it is more likely that the nutrient and toxin release into areas in the vicinity of the Irwin and Moore River mouths impacts western rock lobster productivity by impacting the prey of juvenile and adult lobsters and therefore attracting more adults and juveniles to those areas.

A scientific understanding of the productivity dynamics of western rock lobster lifecycle at river mouths and ground water upwellings will better inform tactical fishing decisions and stock prediction models.

While the outcomes of research in this area of obvious interest to the western rock lobster industry, this issue is the primary focus of other research organisations and until there is accurate long-term forecasting the knowledge has limited use. The CSIRO and UWA undertake significant research in this area.

Scope potential application of Traditional Ecological Knowledge to inshore western rock lobster research

Through observation and deductive reasoning, Aboriginal people have around 60,000 years of accumulated knowledge pertaining to the ecology and other aspects of Australia's coast. Other fisheries across Australia have made significant advances in better understanding the impact of coastal ecology on fisheries through integrating Traditional Ecological Knowledge (TEK) with conventional scientific knowledge in research projects that revolve around an ethos of two-way-learning.

Adopting the same approach to better understanding the inshore aspects of the western rock lobster lifecycle and ecology (such as impacts of river mouth productivity and increasing puerulus survey resolution) may improve our understanding, result in more efficient research delivery and contribute to the industry's social license to operate.

To this end, the potential application of TEK under a two-way learning process to better understand the inshore aspects of western rock lobster lifecycle and ecology, as well as partnerships to give effect to this understanding should be explored. This is the primary responsibility of WRL and while not of immediate urgency, this area should be considered to be of moderate criticality.

Snapper and the western rock lobster food web

Western rock lobster share habitat and some aspects of diet with many demersal species of fish native to Western Australian waters. By virtue of concurrence of natural distribution and relative abundance, various species of snapper present the greatest source of demersal fish competition for food with western rock lobster.

Therefore, ecological impacts or management measures that impact on the snapper population that exists in the same distribution as western rock lobster will impact on the ecology that supports western rock lobster stocks.

A scientific understanding of the relationship between snapper species and western rock lobster in the food web will inform fishing tactics and stock forecasting models. However, research into snapper populations is not the primary responsibility of WRL and other factors are likely to have a greater influence on the accuracy of stock forecasting models or fishing tactical decisions. DPIRD is the organisation with a principal research interest in this area.

Impact of microplastics on the western rock lobster fishery

Improved understanding as to the extent of ingress and accumulation of large volumes of microplastics in the world's oceans is a topical issue. Understanding the extent to which microplastics have and are likely to accumulate in western rock lobster habitat, the impact of microplastic accumulation on their habitat, food web, health and product quality will serve to inform stock prediction models and future tactical fishing decisions.

While the outcomes of research in this area of obvious interest to the western rock lobster industry, this issue is the primary focus of other research organisations and until there is accurate long-term forecasting the knowledge has limited use. The CSIRO and UWA undertake significant research in this area and as discussed under Theme 5 Programme A, WRL's main interest in this area is mitigating its release of plastics into the ocean.

Vulnerability of the western rock lobster fishery to ocean acidification

As a result of global climate change, acidification of the ocean along the Western Australian coast is expected to increase. This will impact on aspects of the western rock lobster's habitat and as with crustaceans, the health of the species itself. Some projections suggest that increased ocean acidification may reach a level where it threatens the viability of the fishery.

Determining the specific level of acidification level that will compromise the fishery, understanding indicators of acidification trajectory and developing models that serve to predict when and under what circumstances a critical level of acidification might be reached will better inform future fishing investment decisions.

While the outcomes of research in this area of obvious interest to the western rock lobster industry, this issue is the primary focus of other research organisations and until there is accurate long-term forecasting the knowledge has limited use. The CSIRO and UWA undertake significant research in this area.

Theme 1 Programme C: Certainty in stock assessments

The following Table 26 summarises the research programmes that are not high criticality and high urgency in Figure 7.

TABLE 26 - THEME 1 PROGRAMME C: CERTAINTY IN STOCK ASSESSMENTS

Research Areas
High Criticality, Low Urgency
Integrating enhanced understanding of and impacts on western rock lobster lifecycle, habitat and ecology into predictive modelling

As a greater understanding of the causes of anomalies in the predictive models is generated by research conducted under Theme 1 Programs A and B, algorithms need to be developed, ground-truthed and integrated into more reliable predictive models.

This issue is a shared responsibility with DPIRD and is considered by industry to be an issue of high criticality and medium to high urgency, primarily because it is dependent on outcomes from research in Theme 1 Programmes A and B.

Low Criticality, High Urgency

Innovation in stock assessment methods

The current stock assessment models used by DPRID are primarily statistics oriented – whereby they identify and model correlations between measurable observations such as breeding stock and puerulus settlement with future recruitment of adult lobsters to the fishery.

Advances in the understanding of western rock lobster biology and lifecycle, habitat and ecology combined with advances in biomath capability (via methods and computing power), present pathways for innovation in stock assessment models, potentially providing more efficient and reliable means for predicting future stock levels. This is considered to be of medium-to-high criticality and urgency and is a shared responsibility with DPIRD. Potential partners in this area could also include UWA, CSIRO and Pawsey Centre, as well as potential expertise from other jurisdictions across the globe.

Increased geographic resolution of puerulus surveys

A recent noted decrease in the geographical resolution of DPIRD's puerulus surveys questions the reliability of the forecasting models. While this is likely the result of reduced budget and is arguably defendable as long as the commercial catch is below Maximum Sustainable Yield. Regardless, it still results in a reduced level of data to inform decisions.

Maintaining an optimal resolution of puerulus settlement surveys serves both regulatory and industry decision-making purposes. This issue is a shared responsibility with DPIRD that is considered to be both critical and urgent.

Theme 2 Programme B: Optimising maximum sustainable yield (MSY) modelling

The following Table 27 summarises the research programmes that are not high criticality and high urgency in Figure 9.

TABLE 27 - THEME 2 PROGRAMME B: OPTIMISING MAXIMUM SUSTAINABLE YIELD (MSY) MODELLING

Research Areas

Low Criticality, Low Urgency

Setting the recreational catch according to Maximum Social Yield

Just as profit and natural resource conservation outcomes are optimised when the TACC is set according to MEY, theoretically, social and natural resource conservation outcomes could be maximised if the Total Allowable Recreational Catch (TARC) was set according to a Maximum Social Yield.

Theoretically a model that determines Maximum Social Yield would use algorithms that set a maximum yield based on inputs based on recreational fisher behaviour who are motivated by

recreation (fishing and dining), rather than profits. The components of and methodology to determine Maximum Social Yield would need to be established as part of this research priority.

Total Allowable Catch and sector quota set in accordance with effective MEY and Maximum Social Yield model outcomes would result in optimal commercial and recreational outcomes, combined with optimal natural resource conservation outcomes across the western rock lobster fishery.

This issue is considered to be of medium criticality and urgency and is a share responsibility with Recfishwest and DPIRD. Other partners could include UWA and CSIRO.

Theme 3 Programme A: Digitisation of industry information systems

The following Table 28 summarises the research programmes that are not high criticality and high urgency in Figure 10.

TABLE 28 - THEME 3 PROGRAMME A: DIGITISATION OF INDUSTRY INFORMATION SYSTEMS

Research Areas

High Criticality, Low Urgency

Scoping an online quota trading platform

An online system that allows MFL holders to buy and sell quota during the season on a real-time basis with certainty of ownership allows fishers to adjust fishing tactics and manage opportunity and risk optimally within a season and if required, on a daily basis.

In an Individual Transferrable Quota management system supported by a competent quota register, real-time online quota trading is technically feasible using existing online, database and block-chain technology. However, its implementation in the western rock lobster industry presents a number of challenges that need to be considered and navigated in its design. These include industry structural challenges (for example, like most online trading systems, the introduction of online quota trading would likely disrupt existing conventional quota trading services in the industry), operational issues (for example, quota is often shared by multiple MFL holders, complicating block-chain real-time reconciliation) and administrative issues (for example, quota certificates would need to be digitised *and individual MFL identifiers would need to be linked to specific units of quota*).

A discussion paper setting out the opportunities and challenges, benefits and drawback of online real time quota trading and solutions to problems and opportunities would make a significant contribution to allowing industry to make an informed decision as to if and how to progress toward an online quota trading platform. Progressing this issue to a conclusion is considered an issue of high criticality and urgency and is a shared responsibility with DPIRD. Potential collaborators include private sector ICT service companies.

Provenance traceability for processed product

The distinct morphology, panmictic and endemic nature of the western rock lobster population means that systems to verify provenance for live, whole-fresh-chilled or whole-frozen product are less necessary for western rock lobster. However, in markets that are served by more processed forms of western rock lobster such as tails, half-half lobsters or cutlets, traceability of provenance may become increasingly important.

Traceability issues associated with potential toxicity are addressed in Section 3.4.4.

A study that examines the state-of-the-art in, and trajectory of, seafood traceability technology and scopes its application in the western rock lobster supply chain for various product forms is the first step in developing a business case for enhanced traceability of processed western rock lobster product.

Progressing this issue to a conclusion is considered an issue of high criticality and urgency and is a shared responsibility with the downstream western rock lobster supply chain. Potential collaborators include private sector ICT service companies and the western rock lobster downstream supply chain industry.

Low Criticality, Low Urgency

Automated lobster measuring systems

Currently, the measurement of caught Lobster is undertaken manually by hand. This is a significant use of labour resources and source of productivity penalty in the western rock lobster fishing process.

A study that scopes the potential to use state-of-the-art visual recognition technology to not only automate the measurement of lobster, but to also identify other characteristics that are useful for fishing operations decisions (such as identification of berried females) and management and stock forecasting decisions (such as estimated age) will create a pathway toward the development of automated onboard catching handling and processing systems and the generation of data that can be analysed to inform both fishing tactics and regulators.

This issue is considered to be of medium criticality and urgency and is principally the responsibility of WRL. Potential collaborators in include Curtin University and private sector automation service providers.

Theme 3 Programme B: Occupational health and safety

The following Table 29 summarises the research programmes that are not high criticality and high urgency in Figure 11.

TABLE 29 - THEME 3 PROGRAMME B: OCCUPATIONAL HEALTH AND SAFETY

Research Areas

High Criticality, Low Urgency

Accredited lobster fishing OHS induction course

The nature of western rock lobster fishing operations are that they present a relatively high OHS risk environment. This exposes western rock lobster businesses to the significant penalties and litigation risk presented by Western Australia' new OHS regulations.

A safer operating environment and mitigation of this risk can be achieved by the development of standard western rock lobster OHS induction course that all workers are required to attain accreditation prior to working on a vessel.

WRL has already invested in this space, contributing to the development of generic fishing industry modules, and the development of lobster industry specific modules. A mobile application supporting the modules is currently at a trial phase.

This area is considered to demonstrate low criticality and low urgency because a substantive amount of work has already been undertaken in this area, with the immediate next step being to translate the trial programme into practice. Because there is significant overlap with the OHS

environment of other fishing sectors, it is considered a shared responsibility with WAFIC. Potential partners in the research include the TAFE sector.

Low Criticality, Low Urgency

Development of an industry mental health programme

The non-nine-to-five shifts that are characteristics of the western rock lobster industry, combined with increasingly longer stints at sea and financial uncertainty for both western rock lobster business owners and workforce, presents circumstance that is conducive to a relatively high incidence of mental health issues among the western rock lobster workforce.

A review of previous studies into the instance and nature of mental health issues and industry responses in the global fishing industry combined with mental health survey of western rock lobster members and the workforce would provide a platform for developing industry support programs for western rock lobster business owners and the workforce. This should be undertaken in the context of work that has already been undertaken by the FRDC.

This issue is considered to be of low criticality and low urgency. It is an area is a major focus of other organisations that could be leveraged by WRL. Potential partners include organisations in the significant mental health NGO sector.

Theme 3 Programme C: Workforce

The following Table 30 summarises the research programmes that are not high criticality and high urgency in Figure 12.

TABLE 30 - THEME 3 PROGRAMME C: WORKFORCE

Research Areas

High Criticality, Low Urgency

Training in ICT systems

The operation of the fishing effort will become increasingly ICT intensive, requiring operators to have a working knowledge of ICT systems more generally as well as the specific tools and software applications that are used onboard.

As systems are deployed, it is likely that short courses will be required to instruct operators on their use and maintenance.

Because this is dependent on significant further digitisation it is considered an issue of high criticality, but medium urgency. It is also an area that is a major focus of other organisations including the TAFE sector and private training service providers.

Theme 3 Programme D: Fishing systems

The following Table 31 summarises the research programmes that are not high criticality and high urgency in Figure 13.

TABLE 31 - THEME 3 PROGRAMME D: FISHING SYSTEMS

Research Areas

High Criticality, Low Urgency

● **Assessment of technological impact on fishing productivity**

As with all primary industries, continued productivity growth is vital to maintaining competitiveness in global markets. In wild-capture sectors there is limited opportunity to address productivity through means that are available to farming sectors such as genetics, nutrients and husbandry practice. As such, the majority of the process on productivity improvement is on the fishing systems.

A study that maps the implication historical improvements western rock lobster fishing technology against productivity gains would provide a benchmark that can be used to set future productivity gain targets, prioritise investment in fishing systems innovation based on their likely impact on productivity growth and be used as an input to allow long-term stock models to accurately account for the impact of the future fishing effort.

This also applies to the recreation sector, where technology can have a dramatic impact on the catch which in turn has implications for setting recreational catch limits.

This issue is considered to be of medium criticality and urgency and is primarily the responsibility of WRL. Potential partners include UWA, Curtin, CSIRO and private sector consultancies.

Theme 4 Programme D: Market Access

The following Table 32 summarises the research programmes that are not high criticality and high urgency in Figure 17.

TABLE 32 - THEME 4 PROGRAMME D: MARKET ACCESS

Research Areas

High Criticality, Low Urgency

● **Geographic traceability within the fishery**

For reasons discussed above, traceability of live or whole-fresh-chilled product has little value in the western rock lobster industry. However, in the event of a localised toxicity issue within the fishery, the ability to identify the specific or regional point of origin of a lobster taken from the fishery may prove important to the continued operation of the overall fishery in such circumstances.

Research that develops and validates forensic techniques for identifying the geographic origin of a lobster would build this risk mitigation capability.

This issue is primarily a WRL issue and is considered to be of low to medium criticality and urgency. Potential partners include Curtin, UWA and DPIRD.

Theme 4 Programme E: Industry Dynamics

The following Table 33 summarises the research programmes that are not of high criticality and high urgency in Figure 18.

Table 33 - Theme 4 Programme E: Industry Dynamics

Research Areas

Low Criticality, Low Urgency

🔴 **Monitoring and reporting on structural change**

The western rock lobster industry is undergoing structural change. Providing western rock lobster businesses with evidence-based analysis on the trends and status of this change and its potential implications will assist those businesses with making strategic and investment decisions.

This is primarily the responsibility of WRL and is considered to be of medium to low urgency and criticality.

Theme 5 Programme A: Ecological impacts of the western rock lobster industry

The following Table 34 summarises the research programmes that are not of high criticality and high urgency in Figure 19.

Table 34 - Theme 5 Programme A: Ecological impacts of the western rock lobster industry

Research Areas

High Criticality, Low Urgency

🔵 **Reducing the fishing fleet carbon footprint**

Most of, if not all, western rock lobster fishing vessel drive trains are powered by diesel-fuel internal combustion power plants and are a major driver of the sectors carbon footprint.

A study scoping the case for alternatives such diesel engine efficiency modifications, biodiesel, natural gas and electric drives in the cost of typical western rock lobster fishing vessel steaming patterns will assist in understanding the viability of alternatives and possible pathways to reducing the industry's carbon footprint. Austral Fisheries own transition to carbon neutrality can be used as a core case study.

Carbon neutrality by 2050 will be driven politically. Hence, assessing technical innovations and other institutional options (e.g. blue carbon bonds) will be relevant for the whole fishing industry.

This is an issue of medium criticality and urgency and is shared with other fisheries across the Nation. Potential partners are vessel designers and power plant manufacturers.

🔵 **Impact of the fishing effort on megafauna**

Managing the impact of the fishing effort on marine fauna has been a topical issue for some time. Because significant research has been undertaken in this area resulting in successful mitigation outcomes, it is less of a critical and urgent issue than it was. However, there remains a requirement to ensure continuous improvement. This is an issue shared with SRL, with potential partners being fishing equipment manufacturers.

> *Because significant research has been undertaken to date in this area, the need is to inform continuous improvement in managing impact. Therefore, this area is deemed to be of relatively low urgency and criticality.*

Appendix 2 – State-of-the-Art

As with all strategic research plans, it is vitally important that priorities are developed with an understanding of the 'state-of-the-art' in key target areas. To this effect, the planning process that has resulted in the current Western Rock Lobster research priorities framework has included a literature review in each of the identified program areas dating back to 1970. It should be noted that by virtue of the likely existence of significant 'grey' literature and publications that pertain to Western Rock Lobster issues but only in a subordinate sense, this review is not likely to be comprehensive. However, it should have identified key historical research that has made substantive contribution to the current state-of-the-art in the identified themes and programs.

In total, the literature review has identified 130 publications who primary research outcomes are targeted at issues associated with the theme and programs that comprise the Western Rock Lobster research priorities framework. As illustrated in Figure 24 below, the majority of this research has taken place since 2000.
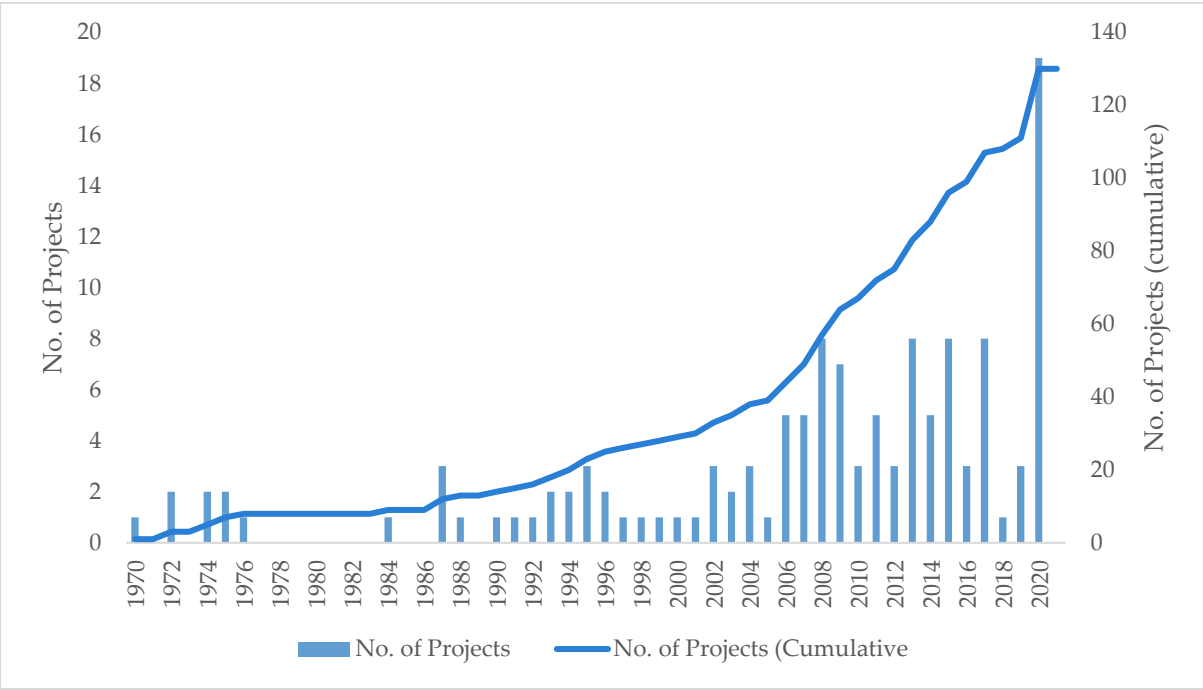
FIGURE 24 – FREQUENCY OF RESEARCH REPORTING UNDERTAKEN IN THE WESTERN ROCK LOBSTER INDUSTRY

As discussed below and seen in Figure 25, more than half of the historical research undertaken has centred around Theme 1 - Western rock lobsters' lifecycle, ecology and stock assessments.

Legend:
- Theme 1: Western Rock Lobster lifecycle, ecology and stock assessments
- Theme 2: Better informed TACC decisions
- Theme 3: Enhanced fishing operations
- Theme 4: Evidence-based policy, industry and market intelligence
- Theme 5: Enhancing social license to operate
- Theme 6: Supporting the adoption of research outcomes by industry and communication to stakeholders
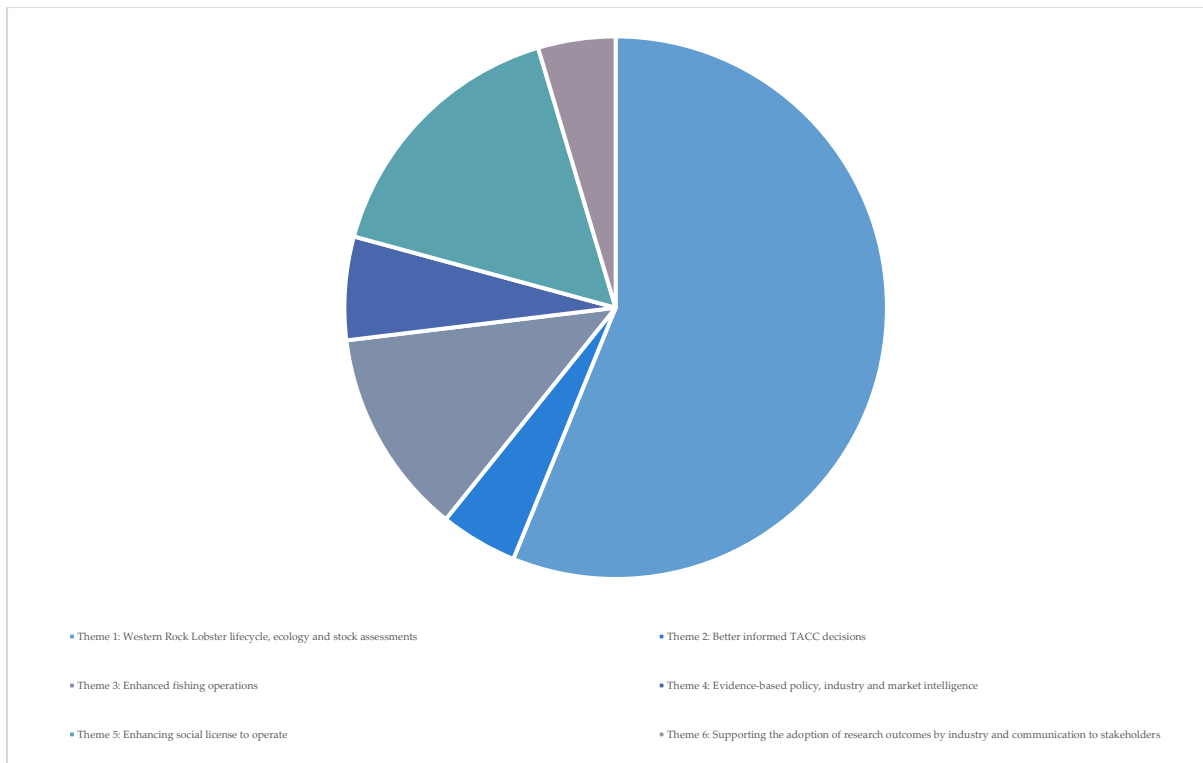
FIGURE 25 – WESTERN ROCK LOBSTER RESEARCH PRIORITIES PLAN FOCUS OF HISTORICAL RESEARCH UNDERTAKEN IN THE WESTERN ROCK LOBSTER INDUSTRY

The following subsections discuss each of the themes that comprise the Western Rock Lobster research priorities framework including the rationale underpinning the theme, specific programs under each theme, the historical research that has been undertaken in support of each program and identification of priority research project areas.

Theme 1: Western rock lobster lifecycle, ecology and stock Assessments

Having an adequate evidence-based understanding of species lifecycle and ecology and being able to measure and predict stock levels and structures is fundamental to both opportunity identification and risk management in any sector of the commercial fishing industry.

Having an optimal and scientific knowledge of the lifecycle of the western rock lobster, the ecology that supports that lifecycle, factors impacting lifecycle and ecology and the ability to apply that knowledge for important practical purposes such as predicting stock levels and structure underpins a range of issues at an industry and enterprise level, including:

- Determining the current and future sustainability of the resource and therefore the optimal harvest strategy from a sustainability perspective;
- Informing decisions around the optimal economic harvest strategy;
- Informing tactical fishing decisions at an enterprise level;
- Underpinning understanding of the ecological impact of western rock lobster fishing (see Theme 5 Program A) and therefore ability to manage the industry's social license to operate); and
- Underpinning ongoing MSC accreditation

Of the themes that comprise this research priorities framework, Theme 1 is the most extensively researched, with the literature review having identified 80 publications that pertain primarily to western rock lobster biology, ecology and stock assessments dating back to the early 1970s.

Detailed in the following subsections, Theme 1 is comprised of the following research programs:

- Program A: Western rock lobster lifecycle and biology
- Program B: Western rock lobster habitat and ecology
- Program C: Certainty in western rock lobster stock assessments

Program A: Western rock lobster lifecycle and biology

Program A of Theme 1 focuses on advancing industry's understanding of the fundamental biology of western rock lobster and its lifecycle, including animal behaviour and movement from mating, through egg production, puerulus stage, juvenile lobster, whites and adults. It also focuses on understanding the biological and genetic structure of the western rock lobster population.

Endemic to Western Australia, the western rock lobster (*Panulirus cygnus*) is one of four species of spiny (or rock) lobster native to Australian waters, with other commercial species being Southern Rock Lobster (*Jasus edwardsii*), Eastern Rock Lobster (*Sagmariasus verreaux*) and Tropical Rock Lobster (*Panulirus ornatus*). As illustrated in Figure 26[5] below, the natural distribution of western rock lobster is approximately from the vicinity of Onslow in the North to Albany in the South, with the main concentration of commercial fishing effort being between Perth and Kalbarri.
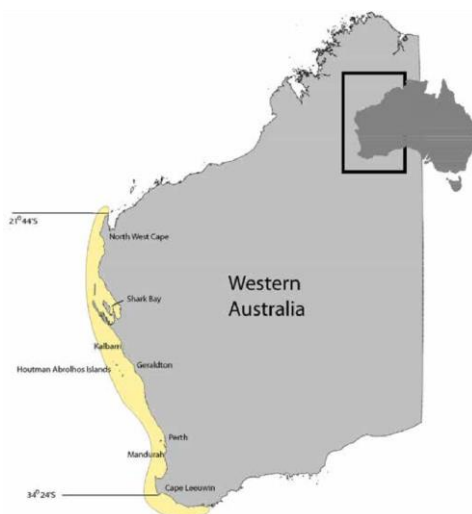
FIGURE 26 – DISTRIBUTION OF WESTERN ROCK LOBSTER

Most aspects of the lifecycle of the western rock lobster are reasonably well understood[6]. Briefly, western rock lobster reach sexual maturity at between six and seven years of age. The mating process occurs in August-September, whereby the male attaches a packet of sperm (known as a 'tarspot') to the underside of a female. During the period September to February, sexually mature females will release unfertilised eggs and by scratching at the tarspot, fertilising those eggs as they are swept backward along her body becoming attached to sticky fine

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[5] Bellchambers, L. and Chandrapavan, A. (2012), *Western Rock Lobster ecology – the state of knowledge*, Marine Stewardship Council Principle 2 – maintenance of ecoystem
[6] Western Rock Lobster Council, Lifecycle Western Rock Lobster

hairs (known as setae) located on the endopodites beneath the tail. A female carrying fertilised eggs on her setae is referred to as being 'berried'.

Depending on water temperature, eggs will hatch in four to six weeks from being fertilised releasing planktonic larvae of around 2 millimetres in length known as phyllosoma. The phyllosoma then drift offshore and spend between nine and eleven months in the open ocean between 400 and 1,000 kilometres off the Western Australian coast. While mortality rates resulting from predation or other causes are high, surviving phyllosoma will undergo a series of moults reaching around 35 millimetres in length as they are eventually carried back to the continental shelf by winds and ocean currents.

Phyllosoma then metamorphosise into miniature, transparent western rock lobster, known as pueruli. With the assistance of prevailing currents, pueruli swim up to 60 kilometres across the continental shelf to settle on inshore reefs, where within days they develop the red colouration and continue to grow through a series of moults over the next three to four years.

In November, juvenile and mature western rock lobster undergo a synchronised moult, changing their colour from their distinctive red, to a creamy-white or pale pink. Known as 'whites', they then migrate in large groups at night until they reach spawning-grounds in waters of up to 100 metres in depth and then return to their normal red colour at the next moult in a few months' time.

The literature review informing this research priorities plan has identified 32 publications pertaining to Program A since 1970, with around half of those publications published in the past 20 years. There is a notable concentration of research completed in the period 2006 to 2014. This is illustrated in the following Figure 27.
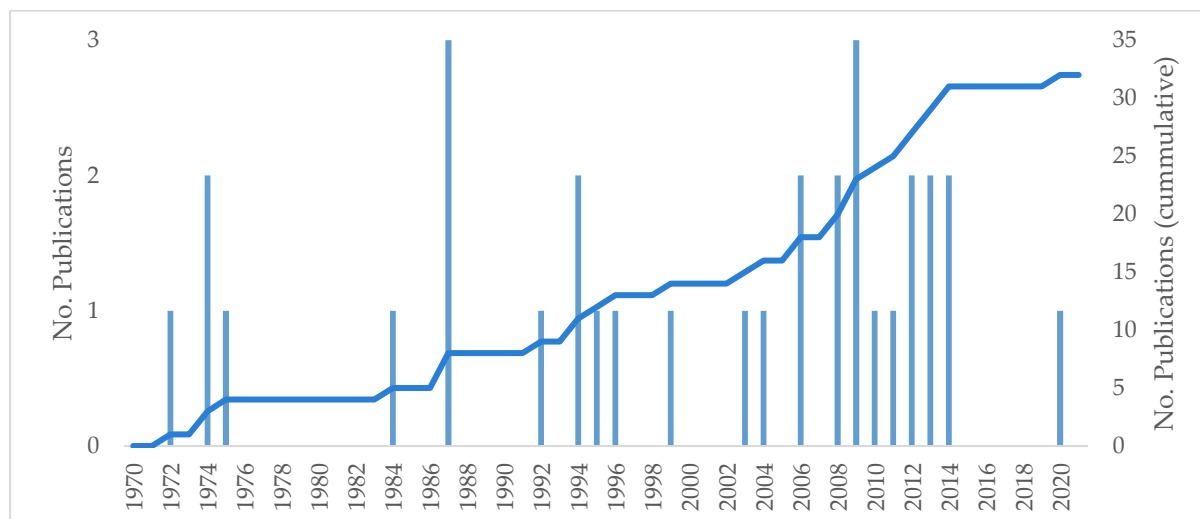
FIGURE 27 – FREQUENCY OF RESEARCH REPORTING UNDER THEME 1: PROGRAM A – WESTERN ROCK LOBSTER LIFECYLE AND BIOLOGY

The primary focus of historical projects undertaken under Program A has been reproduction and growth and nutrition and food web aspects of the western rock lobster lifecycle. This is illustrated in the following Figure 28. Each of these sub-themes are discussed in detail in the sections that follow.
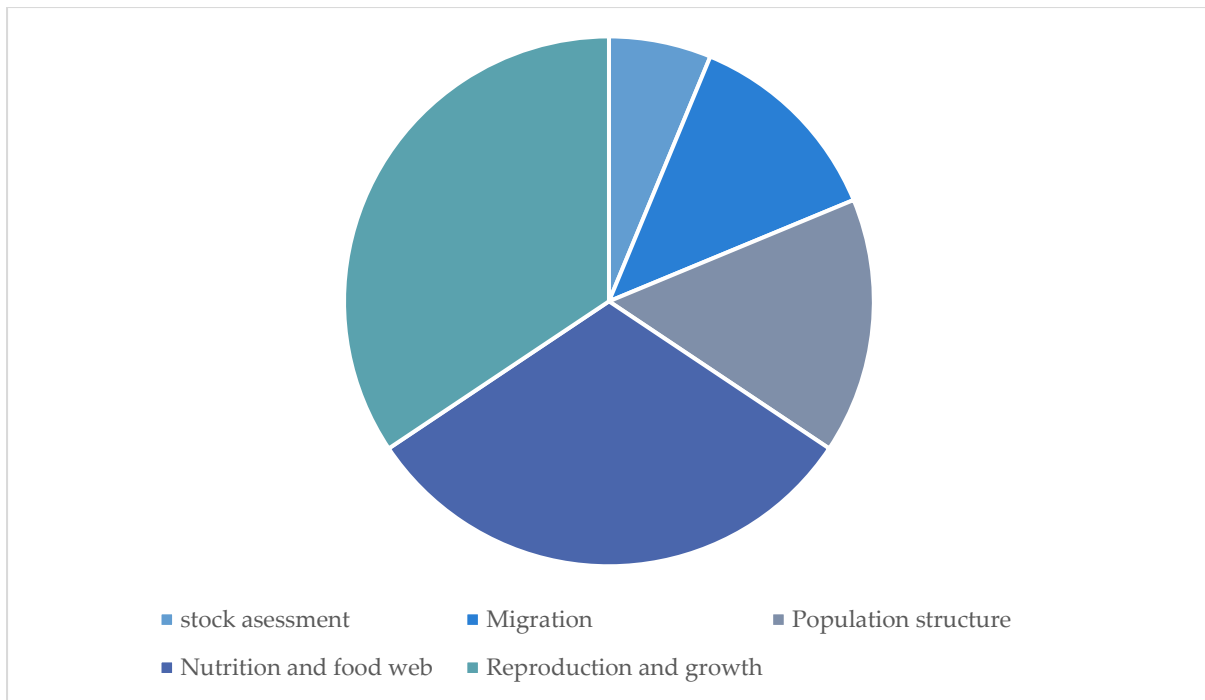
FIGURE 28 – MAIN TOPICS OF FOCUS OF HISTORICAL RESEARCH UNDERTAKEN UNDER THEME 1: PROGRAM A

Reproduction and growth

The main focus of over one-third of the historical research projects relating to Theme 1 Program A has been on western rock lobster reproduction and growth. Key areas of investigation have included:

- **Fecundity** – factors influencing the ability of female western rock lobster to produce an abundance of offspring have contributed to an understanding:
  - That there is little variation in fecundity across the population, whereby an early study indicates that fecundity does not vary along the Western Australian coastline
  - That egg loss during incubation is relatively low and the portion of infertile eggs is independent of carapace length[7].
  - Of the breeding implications of the setose and maximum size rules. This study implies that egg diameters are significantly smaller at the Abrolhos Islands than at the coast and quantifies the extent of the breeding grounds, so as to weight the overall egg production index for the stock by contribution of the management zones.[8]
  - The moult cycle, size and breeding patterns throughout the year for female western rock lobster, which informs management measures designed to protect females in setose condition.[9]

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[7] Morgan, G. (1972), 'Fecundity in the Western Rock Lobster', *Marine & Freshwater Research*, CSIRO Publishing

[8] Melville-Smith, R., de Lestang, S., Beale, N., Growth, D. and Thompson, A. (2003), *Investigating reproductive biological issues relevant to managing the Western Rock Lobster broodstock*, Fisheries Research and Development Corporation and Department of Fisheries, Western Australian Government

[9] De Lestang, S. and Melville-Smith, R. (2006), 'Interannual variation in the moult-cycle and size at double breeding of mature female Western Rock Lobster', *ICES Journal of Marine Science*, 63(9), 1631-1639

- **Prevalence of polyandry** – a study investigating the rates of polyandry within wild western rock lobster populations determined that while a significant number of females had attached spermatophores arising from at least two males (confirming polyandry), there was limited evidence of multiple paternity within a single group of offspring.[10]

- **Growth rates** - understanding western rock lobster growth rates and factors influencing growth rates has been a significant focus:
    - A study exploring longitudinal data over a 32-year period pertaining to the sizes at which male and female western rock lobster become mature indicates that size at maturity correlates to water temperature and identifies an overall trend of declining size at maturity over a 20-year period.[11]
    - A study exploring growth patterns in western rock lobster reared in captivity identified that improved growth rates from puerulus to adulthood resulted in larger size at maturity and eliminated differences in growth between juvenile males and females that is evident in the natural population but did not result in earlier maturity. It also found that first breeding ages ranged from 4.9 years to 5.7 years. When the controlled environment water temperature was held at 25^0C, repetitive breeding occurred in contrast to the seasonal breeding that occurs in the wild population. However, ecdysis (the process of casting off the outer cuticle) did not always occur between each breeding cycle, but a fresh mating was required for the fertilisation of each batch of spawned eggs.[12]
    - Another study that modelled the growth rate of western rock lobster, ornate lobster and Caribbean lobster demonstrated that western rock lobster grows at a slower rate than tropical lobster species, with all species demonstrating significant variability in growth rate between individuals. This study also indicated that tagging and handling spiny lobsters can contribute to decreased growth rates.[13]
    - A study exploring density of puerulus settlement in two locations – Seven Mile Beach and Cliff Head and on reef ledges and in caves found significant differences in settlement densities in locations and in caves and ledges and suggests that higher growth rates are achieved from locations where settlement density is less.[14]
    - A study proposed a method for fitting growth curves to multiple recapture data of lobsters when the age at first capture is unknown.[15]
    - A study modelling catch indicates that proportions of three and four year old post-settlement lobsters contributing to the catches varies markedly from the

[10] Loo, J., Kennington, W., de Lestang, S., How, J. and Evans, J. (2020) 'High levels of polyandry, but limited evidence for multiple paternity in wild populations of the Western Rock Lobster', *Ecology and Evolution*, 8(9), 4525-4533

[11] De Lestang, S. and Melville-Smith, R. (2006) 'Spatial and temporal variation in the size at maturity of the Western Rock Lobster', *Marine Biology*, 150(2), 183-195

[12] Chittleborough (CSIRO) (1974), 'Western Rock Lobsters reared to maturity', *Australian Journal of Marine and Freshwater Research*, 25(2), 221-225

[13] Phillips, B., Palmer, M., Cruz, R. and Trendall, J. (1992), 'Estimating growth of the spiny lobsters *panulirus cygnus*, *P. argus* and *P. onatus*', *Marine & Freshwater Research*, CSIRO Publishing

[14] Jernakoff, P., Fitzpatrick, J., Phillips, B. and de Boer, E. (1994) 'Density and growth in populations of juvenile Western Rock Lobsters', *Marine & Freshwater Research*, CSIRO Publishing

[15] Cheng, Y. and Kuk, A. (2004) 'Determination of the unknown age at first capture of Western Rock Lobsters by random effects model', *Journal of the International Biometrics Society*, 58(2), 459-462

southern and northern transects of the fishery, suggesting that juvenile lobsters grow faster in the warmer northern and offshore waters.[16]

o   Using computer simulation, a study modelled ocean circulation to understand its effects on the settlement of western rock lobster larvae. This study indicates that larvae hatching in late spring and early summer grow fastest and have the greatest chances of survival, and that the Abrolhos Islands are the most important hatching area in terms of successful settlement.[17]

Migration

As discussed above, large-scale migration is a key aspect of various stages of the western rock lobster lifecycle. However, the frequency of large-scale, long distance migration along the western rock lobster lifecycle, means that recruitment of adult lobsters into the fishery is subject to factors such as shelf width and metocean conditions that affect cross-shelf transportation and abundance of nutrition (see below). This results in considerable variation in spatial and temporal recruitment.

As discussed below, historically statistical methods of predicting recruitment have been highly reliable. However, more recent anomalies in the accuracy of these methods suggests that understanding of migration patterns and factors that influence those patterns is suboptimal, compromising the ability to forecast stocks.

Historical research in this space has focused on both puerulus and juvenile migration, as well as lobster movements more generally:

- **Puerulus migration** - a study investigating the swimming behaviour of puerulus observed speeds of up to 33 cm/second against currents of between 9 and 13 centimetres per second and found that puerulus larvae swim alone and are capable of avoidance reactions by a rapid flexing of the abdomen, and also of detecting objects in the water.[18]

- **Juvenile lobster migration** – migration of whites in November to January involves immature lobsters of around 70 to 90 mm carapace length migrating offshore in a west to north-westerly direction. They generally move less than 50 kilometres to recruit to the breeding stock areas (40 to 100 metres in depth) adjacent to the nursery grounds where they settled as pueruli. However, some white lobsters undertake long distance northerly migrations (up to 440 kilometres), usually in very deep water (greater than 100 metres depth) before settling in the breeding stock areas close to shore. A more recent study demonstrates that western rock lobster migration is associated with body size and water depth, and that magnetism and oceanic currents appear to be the most likely guideposts used for orientation. According to this study, size at migration varies in a constant fashion along the Western Australian coast, being larger towards the southern end of the fishery and smallest at the offshore Abrolhos Islands.[19]

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[16] De Lestang, S., Caputi, N. and Melville-Smith, R. (2009), 'Using fine-scale catch predictions to examine spatial variation in growth and catchability of *panulirus cygnus* along the west coast of Australia', *New Zealand Journal of Marine and Freshwater Research*, 43(1), 443-455

[17] Feng, M., Caputi, N., Penn, J. and Slawinski, D. (2011) 'Ocean circulation, Stokes drift and connectivity of the Western Rock Lobster (*Panulirus cygnus*) population', *Canadian Journal of Fisheries and Aquatic Sciences*, 68(7), 1182-1196

[18] Phillips, B. and Olsen, L. (1975) 'The swimming behaviour of the puerulus stage of the Western Rock Lobster', *Australian Journal of Marine and Freshwater Science*, CSIRO Publishing, 26(3)

[19] De Lestang, S. (2014), 'The orientation and migratory dynamics of the Western Rock Lobster', *ICES Journal of Marine Science*, 71(5), 1052-1063

- **Biological navigation -** a study suggests that complex receptor systems formed by the antennae and the pinnate setal system of the western rock lobster perform a role in navigation by allowing the lobster to orient to vibrational cues associated with the coast.[20]

- **General lobster movements -** research has demonstrated that with the exception of the major migratory events, western rock lobster are reasonably sedentary. An early study into the home ranges of juvenile western rock lobsters found that in an uncrowded reef, home range does not exceed 15 metres and that lobsters relocated to new sites rarely remained at the new location, with some finding their way back to the original reef (from distances of up to 400 metres) and other dispersing at random, travelling up to 8.3 kilometres in nine weeks[21].

Nutrition and food web

Around one-third of historical research relevant to Theme 1: Program A has focused primarily on understanding western rock lobster nutrition and its participation in the food web.

Sheltering in caves and under reef ledges during the day, western rock lobster are omnivorous nocturnal feeders that forage on reef systems and seagrass beds in close proximity to their daytime shelter.

Historical research in this area has focused on:

- **Phyllosoma diet** – studies understanding the diet of western rock lobster in phyllosoma and larval life stages have included:
  o On-board feeding trials investigating western rock lobster larvae food preferences and nutritional requirements that indicated that chaetognaths were consumed in two to eight times higher numbers than other prey. When consumed over six days, western rock lobsters demonstrated an improvement in overall nutritional condition.[22]
  o An additional study using DNA sequencing to identify a range of food sources of western rock lobster larvae identified a range of previously undetectable gelatinous zooplankton as common to their diet, particularly colonial radiolarians.[23]
  o Another study assessed the various food sources and nutritional value in cyclonic and anticyclonic eddies of the Leeuwin Current, suggesting that by virtue of higher lipid and energy storage content of phyllosomas in cyclonic eddies, the microbial food web that operates in the cyclonic eddies provide better feeding conditions for western rock lobster larvae than those present in anticyclonic eddies.[24]

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[20] Macmillan, D., Phillips, B. and Coyne, A. (1987), 'Antennal receptors in the puerulus and post-puerulus stages of the rock lobster and their potential role in peurulus navigation', *Marine Behaviour and Physiology*, 19(3), 211-225

[21] Chittleborough, R. (1974)'Home range, homing and dominance in juvenile Western Rock Lobsters', *Marine & Freshwater Research,* CSIRO Publishing 25(2)

[22] Saunders, M., Thompson, P., Jeffs, A., Sawstrom, C., Sachlikidis, N., Beckley, L. and Waite, A. (2012) 'Fussy feeders: phyllosoma larvae of the Western Rock Lobster', *PLoS ONE*, 7(5)

[23] O'Rorke, R., Lavery, S., Chow, S., Takeyama, H., Tsai, P., Beckley, L., Thompson, P., Waite, A. and Jeffs, A. (2012) 'Determining the diet of larvae of Western Rock Lobster using high throughput DNA sequencing techniques' *PLoS ONE* 7(8)

[24] Wang, M., O'Rorke, R., Waite. A., Beckley, L., Thompson, P. and Jeffs, A. (2014) 'Fatty acid profiles of phyllosoma larvae of Western Rock Lobster in cyclonic and anticyclonic eddies of the Leeuwin Current' *Progress in Oceanography*, 122, 153-162

- **Relationship between nutrition and recruitment** – studies endeavouring to understand the relationship between nutrition and recruitment of puerulus include:
    - One study investigating the levels of lipid, fatty acids and proteins in puerulus and their association with differing habitat factors like shelf width and oceanic conditions and suggests that puerulus nutritional status appears to offer valuable insight into the processes underpinning recruitment of western rock lobster.[25]
    - Similarly, another study demonstrates that variation in settlement is driven by food availability during the larval stage as it is a driver for survival and growth.[26]

- **Foraging behaviour** - Early studies also explored the foraging area and behaviour of western rock lobster.
    - They have shown foraging areas to be varied and much larger than originally thought.[27]
    - Additional studies into foraging patterns found that most foraging activity begins in response to changes in light levels associated with dusk, with lobsters similarly returning from foraging around dawn when light levels start to increase. This study also indicates that foraging activity is constant through the night, with males generally more active than females and lobster moving along their home reef as well as foraging in adjacent seagrass beds.[28]
    - Another study found that nocturnally active western rock lobster forage close to shallow reefs, with around 90 percent of observed lobster activity occurring within 60 metres of the nearest high relief reef.[29]

- **Nutrition and growth rate** - early investigations into western rock lobster nutrition indicate that there is an association between animal-rich diets and plant-rich diets and growth rates, with lobsters living in locations that provide for animal-rich diets growing at faster rates.[30]

- **Location and diet** - later studies explored used isotope and gut content analysis to determine the diet and trophic position of western rock lobster from mid-shelf ecosystems, indicating that western rock lobster located in deep-coastal ecosystems are more carnivorous than their counterparts living in shallow water ecosystems.[31]

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[25] Limbourn, A., Babcock, R., Johnston, D., Nichols, P. and Knott, B. (2009) 'Spatial and temporal variation in lipid and fatty acid profiles of Western Rock Lobster pueruli at first settlement: biochemical indicators of diet and nutritional status', *Marine & Freshwater Research*, 60(8), 810-823

[26] Waite, A. (2010) *The biological oceanography of Western Rock Lobster larvae*, The University of Western Australia

[27] Jernakoff, P., Phillips, B. and Maller, R. (1987) 'A quantitative study of nocturnal foraging distances of the Western Rock Lobster', *Journal of Experimental Marine Biology and Ecology*, 113(1), 9-21

[28] Jernakoff, P. (1987) 'Foraging patterns of juvenile Western Rock Lobsters', Journal of Experimental Marine Biology and Ecology, 113(2), 125-144

[29] Macarthur, L., Hyndes, G., Babcock, R. and Vanderklift, M. (2008) 'Nocturnally active Western Rock Lobster forage close to shallow reefs', *Aquatic Biology*, 4(2)

[30] Joll, L. and Phillips, B. (1984) 'Natural diet and growth of juvenile Western Rock Lobsters', Journal of Experimental Marine Biology and Ecology, 75(2), 145-169

[31] Waddington, K., Bellchambers, L, Vanderklift, M. and Walker, D. (2008) 'Diet and trophic position of Western Rock Lobsters in Western Australia deep coastal ecosystems indicates they are more carnivorous than their counterparts in shallow water ecosystems', *Estuarine, Coastal and Shelf Science*, 79, 114-179

Population structure

The population of the western rock lobster species has long been considered a single, panmictic (random mating) population. While ongoing research in this area has contributed to an improved understanding, it has reinforced that there is little genetic variation between cohorts of western rock lobster:

- A study conducted in the late 1990s identified genetic differences between temporal surveyed cohorts, but confirmed no genetic variation along latitudinal subdivisions.[32]
- A subsequent study identified that previously observed temporal and potential spatial genetic variation in adult western rock lobster is likely the result of ephemeral genetic patchiness that can be generated by the locally specific genetic mix of recruits obtained from a common larval pool.[33]
- A decade later, genetics research focused on investigating the genetic heterogeneity of the western rock lobster population across various locations to determine if there are particular breeding sites that contribute disproportionately to stock. This research estimates the effective population size required to maintain healthy genetic diversity among the western rock lobster population. The results suggest that western rock lobster breeding stock is a single population.[34]
- Later studies further confirmed no significant genetic diversification across the range and that genetic diversity will be maintained under current management conditions.[35,36]

Stock assessment

The following two studies relate the biology and lifecycle of the western rock lobster to stock assessment.

- A study identified that puerulus settlement on collectors correlates well with natural densities of early juveniles on reefs.[37]
- Following the introduction of regional or zone-specific management arrangements in the early 1990s, a study designed to provide a better understanding of regional variations in growth, movement and mortality was required to support models for assessing regional management options.[38]

Further research into stock assessment models is detailed in Section 0.

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[32] Thomspon, A., Hanley, J., Johnson, M. (1996) 'Genetic structure of the Western Rock Lobster with the benefit of hindsight', Graduate Research School University of Western Australia

[33] Johnston, M. and Wernham, J. (1999) 'Temporal variation of recruits as a basis of ephemeral genetic heterogeneity in Western Rock Lobster', *Marine Biology*, 135, 133-139

[34] Kennington, W., Berry, O., Growth, D., Johnson, M. and Melville-Smith, R. (2009) 'Evaluation of population genetic structures in the Western Rock Lobster' Curtin Research Publications

[35] Kennington, J., Cadee, S., Berry, O., Growth, D., Johnson, M. and Melville-Smith, R. (2013) 'Maintenance of genetic variation and panmixia in the commercially exploited Western Rock Lobster' University of Western Australia Graduate Research School

[36] Kennington, J., Berry, O., Growth, D., Johnson, M. and Melville-Smith, R. (2013) 'Spatial scales of genetic patchiness in the Western Rock Lobster', Curtin Research Publications

[37] Jernakoff, P., Fitzpatrick, J., Phillips, B. and de Boer, E. (1994) 'Density and growth in populations of juvenile Western Rock Lobsters', *Marine & Freshwater Research*, CSIRO Publishing

[38] Chubb, C., Rossbach, M., Melville-Smith, R. and Cheng, Y. (1995) *Mortality, growth and movement of Western Rock Lobster*, Fisheries Western Australia and Fisheries Research and Development Corporation

Program B: Western rock lobster habitat and ecology

As with all wild-catch fisheries, a biological and physical habitat and ecology that optimally supports the biology and lifecycle of a health population of western rock lobster is critical to the sustainability of the resource and economics of the fishery.

Theme 1 Program B focuses on achieving an optimal scientific understanding of the habitat and ecology that supports a healthy population of western rock lobster, as well as individual factors that affect that habit and ecology and their cumulative impact.

The literature review has identified a total of 19 publications whose primary focus is on aspects of western rock lobster habitat and ecology, with most of those publications having reported since 2008. This is illustrated in the following Figure 29.
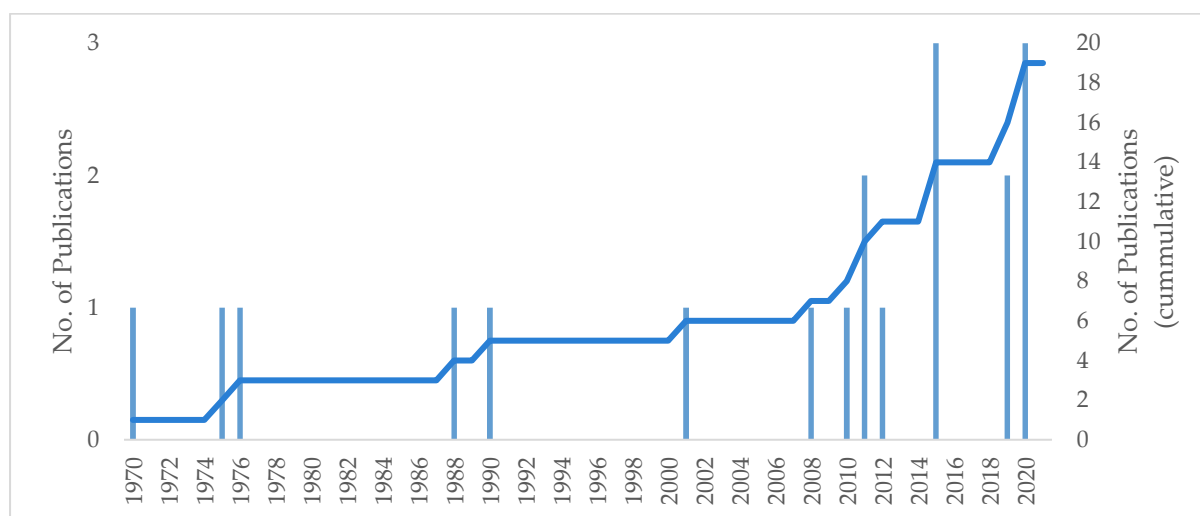
FIGURE 29 - FREQUENCY OF RESEARCH REPORTING UNDER THEME 1: PROGRAM B – WESTERN ROCK LOBSTER HABITAT AND ECOLOGY

As illustrated in the following Figure 30, the main focus of 60 percent of these publications has been on juvenile, adult and general habitat and ecology issues, with larvae and puerulus habit and ecology being a relatively small focus.
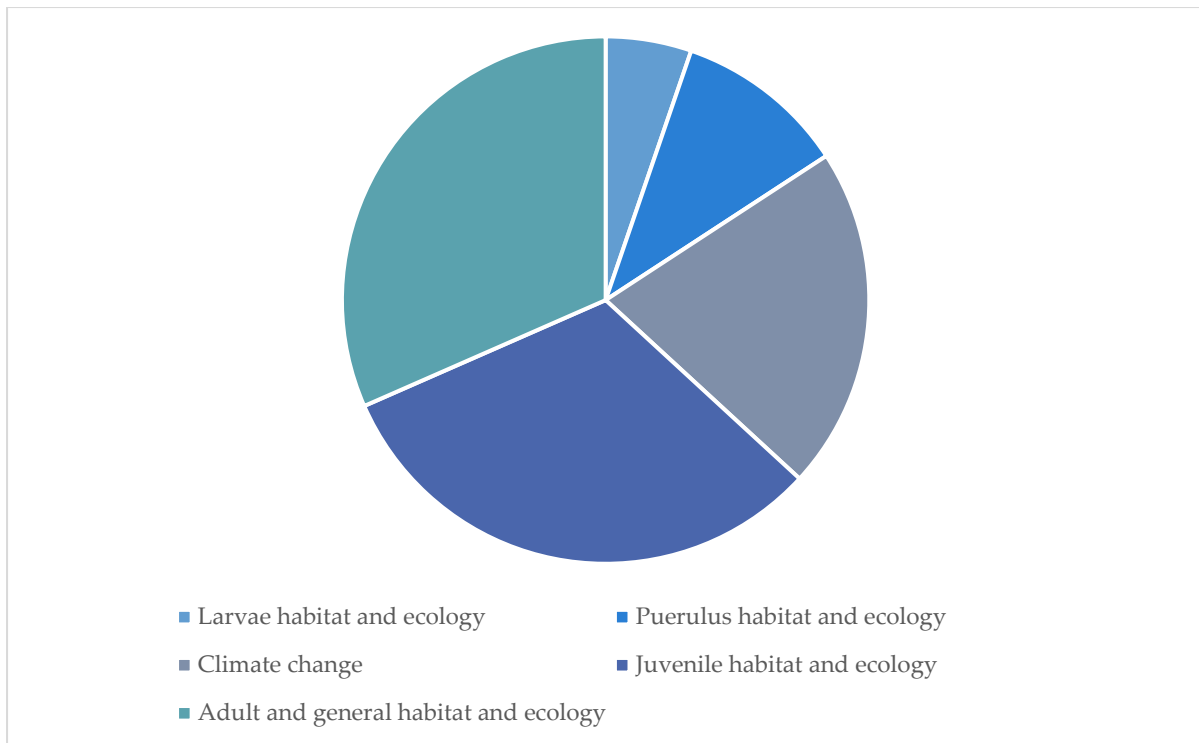
FIGURE 30 - MAIN TOPICS OF FOCUS OF HISTORICAL RESEARCH UNDERTAKEN UNDER THEME 1: PROGRAM B

These are summarised in the following subsections.

Larvae habitat and ecology

A single identified study rejects what was a previously held misconception that prey composition during late larval phase is the primary determinant of larval condition, instead indicating that other ecological conditions are the primary determinants, such as eddy water temperature being responsible for reducing the condition of larvae directly, or indirectly by impoverishing the nutritional value of their food[39].

Puerulus habitat and ecology

The two identified studies exploring issues associated with puerulus habitat and ecology focused on the impact of metocean conditions on puerulus settlement:

▪ One study explored the effects of the Leeuwin Current, prevailing westerly winds and monthly sea-surface temperature on puerulus settlement, and found that when the Leeuwin Current begins to strengthen during February to April, it is highly correlated with puerulus settlement and in years when the current is particularly strong southern areas of the fishery exhibit higher than normal settlement, with sea surface temperature most likely impacting puerulus survival more generally[40].

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[39] O'Rourke, R., Jeffs, A., Wang, M., Waite, A., Beckley, L. and Lavery, S. (2015), 'Spinning in different directions: Western Rock Lobster larval condition varies with eddy polarity, but does their diet?', *Journal of Plankton Research*, 37(3), 542-553

[40] Caputi, N. and Pearce, A. (2001), 'Environmental effects on the recruitment of the Western Rock Lobster', Marine and Freshwater Research, 52(8), 1167-1174

- A subsequent study found that while the strength of the current during the period February to April affects the abundance of puerulus settlement, it is the strength of the current from June onwards that affects the spatial distribution of settlement[41].

Juvenile habitat and ecology

Historical studies into the habitat and ecology of juvenile lobster have a broader focus:

- **Relationship between density in habitat and survival** - an early study examined the impact of density on reefs and other non-density related impacts on juvenile western rock lobster mortality and found that density-related factors appeared to be more important for survival of juvenile western rock lobster on shallow coastal reef ecosystems[42].

- **Relationship between food supply and survival** - a subsequent study exploring the impact of a range of ecological conditions on survival and growth of juvenile western rock lobster in shallow reef ecosystems suggests that food supply is the dominant factor determining growth and survival of western rock lobster[43]. This was confirmed by a study that compared growth rates of captive juvenile lobsters with wild juveniles at various locations that identified competition for or scarcity of food as a major determinant of growth rate[44]. However, the veracity of these findings is somewhat questioned by research conducted a decade later that suggests that trapping techniques used to estimate the density of juvenile lobsters on individual patches of reefs may be biased because lobsters on neighbouring reefs up to 120 metres away could be attracted to the bait, may leave the traps prior to dawn and that traps set less than 120 metres apart may be visited by the same individual animals[45].

- **Impact of marine heatwaves** - a current study is exploring the habitat associations of juvenile western rock lobster and impact of future marine heatwaves on recruitment to the fishery[46].

- **Impact of freshwater input** - a current study is exploring the relationship between freshwater input and seagrass habitat as it relates to juvenile western rock lobster abundance[47].

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[41] Caputi, N. (2008), 'Impact of the Leeuwin Current on the spatial distribution of the puerulus settlement of the Western Rock Lobster fishery in Western Australia', *Fisheries Oceanography*, 17(2), 147-152

[42] Chittleborough, R. (1970), 'Studies on recruitment in the Western Rock Lobster: density and natural mortality of juveniles' *Australian Journal of Marine and Freshwater Ecology,* 21(2), 131-148

[43] Chittleborough, R. (1975), 'Environmental factors affecting growth and survival of juvenile Western Rock Lobsters', *Australian Journal of Marine and Freshwater Research*, 26(2), 177-196

[44] Chittleborough, R. (1976), 'Growth of juvenile panulirus cygnus on coastal reefs compared with those reared under optimal environmental conditions', Australian Journal of Marine and Freshwater Research, (27), 279-295

[45] Jernakoff, P. and Phillips, B. (1988) 'Effect of a baited trap on the foraging movements of juvenile Western Rock Lobsters' *Australian Journal of Marine and Freshwater Research,* 39(2), 185-192

[46] DPIRD (2020), 'Examine habitat associations of juvenile Western Rock Lobster and the impacts of future marine heatwaves on the recruitment to the fishery',

[47] DPIRD (2020), 'Examine the relationship between freshwater input and seagrass habitat as they relate to juvenile Western Rock Lobster abundance'

Adult and general habitat and ecology

A similarly larger portfolio of studies focusing primarily on adult lobster habitat and ecology, but also lobster habitat and ecological issues more broadly focused on:

- **Impact of food quality and prey density** - one study suggests that localised recruitment of the trochid mollusc *Cantharidus lepidus* may be a primary driver of western rock lobster growth rates in specific locations. This further supports the hypothesis that abundance for quality food and prey density are key drivers of western rock lobster growth rate[48].

- **Habitat diversity across the western rock lobster population** - a study investigating the varying sources of food for adult western rock lobster across different habitats found that diet was predominately consistent across all regions, with sandier habitats associated with greater consumption of sessile filter feeders and that macroalgae is most likely an autochthonous energy source[49]. Another study developed an industry-based habitat mapping and monitoring system[50].

- **Impact of fishery closures on habitat** - another study developed an eco-space model to evaluate the impact of fishery closures and other management practices on western rock lobster habitat and noted that changes in biomass resulting from closures was most notable for sedentary species rather than migratory species[51].

- **Impact of submarine groundwater discharge** - a current study is investigating areas of significant submarine groundwater discharge (SGD) located near western rock lobster settlement monitoring sites, the direct role of SGD in western rock lobster settlement rates, the link between SGD and extent and condition of important lobster habitat, identified and map input of contaminants by SGD in key fishery areas and investigate impact of contaminants on the survival of puerulus and post-puerulus lobsters[52].

- **Impact of seismic survey** - a current study is endeavouring to better understand the impacts of shallow water, near shore seismic surveys on western rock lobster mortality rates[53].

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[48] Edgar, J. (1990), 'Predator-prey interactions in seagrass beds: the influence of macrofaunal abundance and size structure on the diet and growth of Western Rock Lobster', Journal of Experimental Marine Biology and Ecology, 139(1-2), 1-22

[49] Macarthur, L., Hyndes, G., Hanson, C., Phillips, D. and Vanderklift, M. (2011), 'Habitat surrounding patch reefs influences the diet and nutrition of Western Rock Lobster', *Marine Ecology Progress Series,* 436, 191-205

[50] De Lestang, S., Pember, M. and Slawinski, D. (2011), *Development of an industry-based habitat mapping and monitoring system,* Fisheries Research and Development Corporation, Western Australian Department of Primary industries and Regional Development and CSIRO

[51] Lozano-Montes, H., Babcock, R. and Loneragan, N. (2012), 'Exploring the effects of spatial closures in a temperate marine ecosystem in Western Australia: a case study of the Western Rock Lobster Fishery', *Ecological Modelling,* 245, 31-40

[52] Langlois, T. (2019), 'Investigation of the direct and indirect role of submarine groundwater discharge on Western Rock Lobster settlement processes: with consideration of the potential role of contaminants', University of Western Australia School of Biological Sciences, School of Agriculture and Environment and Oceans Institute

[53] DPIRD (2020), 'Long term impacts of seismic surveys on lobsters'

Impact of climate change

The main focus of research exploring anthropogenic and other impacts on western rock lobster habitat and ecology has been on the impact of global climate change. This has included:

- **Understanding the likely impact of climate change on metocean conditions** – studies that have explored the effects of climate change of metocean conditions include:
  - An initial study in 2010 noted that climate change is causing an increase in water temperature that is seasonably variable, a weakening of westerly winds in winter and an increase the frequency of El Nino events – all factors which impact western rock lobster reproduction, recruitment, survival and growth rates. Rising water temperatures are resulting in a decrease of lobster size at maturity and size of migrating lobsters from shallow to deep water, increases in the abundance of undersized and legal-sized lobsters in deep water relative to shallow water and resulting shifts in catch to deep water.[54]
  - Another study identified the key environmental trends affecting the Western Australian marine environment as changing frequency and intensity of El Nino-Southern Oscillation (ENSO) events, decadal variability of the Leeuwin Current, increase in water temperature and salinity, change in frequency of storms affecting the lower west coast, change in frequency and intensity of cyclones affecting the north-west and forecast reduced strength of the Leeuwin Current and eddy activity area associated with reduced nutrient supply to the upper ocean and a reduction in phytoplankton concentration and primary productivity in the oligotrophic water off the west coast. The study also notes that sea surface temperature will continue to increase out to the 2060s, that changes in shelf wind stress may be compensated by changes in shelf sea surface height, reducing changes in Capes Current transport and that there is not expected to be any significant change in coastal upwelling. This study identifies western rock lobster as being among six of Western Australia's 35 key commercial and recreational fisheries facing the greatest risk associated with global climate change[55].

- **Specific impact on western rock lobster migration** – a study documented substantial inter-annual variation in the latitudinal distribution (between latitudes 27^0 and 30^0S) of migrating lobsters in deep water. This distribution was found to be highly correlated with the sea-floor meridional current strength in January and mean latitude and abundance of puerulus settlement three to four years previously. Combined, these indices explained 92 percent of the annual variation in the latitude of migration, and the majority of variation in commercial catches toward the north of the fishery. These indices are all directly or indirectly impacted by the Leeuwin Current, which is expected to weaken over the longer term as a result of climate change, possibly leading to greater northward lobster migrations and a shift in the biomass of lobsters toward the northern end of the fishery[56].

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[54] Caputi, N., Melville-Smith, R., de Lestang, S. and Pearce, A. (2010), 'The effect of climate change on the Western Rock Lobster fishery of Western Australia', *Canadian Journal of Fisheries and Aquatic Sciences, 67*(1), 85-96

[55] Caputi, N., Feng, M., Pearce, A., Benthuysen, J., Denham, A., Hetzel, Y., Matear, R., Jackson, G., Molony, B., Joll, L. and Chandrapavan, A. (2015) 'Management implications of climate change effect on fisheries in Western Australia', Fisheries Research Report No. 260, Government of Western Australia Department of Fisheries, Fisheries Research and Development Corporation, CSIRO

[56] de Lestang, S. and Caputi, N. (2015) 'Climate variability affecting the contranatant migration of the Western Rock Lobster', *Marine Biology*, 162, 1889-1900

- **Specific impact on western rock lobster habitat** - current research projects are evaluating the implications of habitat change for western rock lobster by determining the relative importance of habitat for western rock lobster survival and growth during critical stages of the western rock lobster lifecycle, and when specific habitat change is expected to occur with the express purpose of informing the interpretation of existing settlement and recruitment metrics[57].

Program C: Certainty in stock assessments

From both a resource sustainability and commercial management perspective, one of the most important outcomes from historical research relating to western rock lobster has been the development of method for predicting future lobster recruitment into the fishery based on annual surveys of puerulus settlement in specific locations.

Using a statistical methodology that is based on the analysis of correlations between puerulus settlement at certain locations and adult lobster recruitment in four years' time, outcomes from this analysis were key inputs to natural resource management decisions made by the Western Australian Government. For example, between 2006-07 and 2010-11, puerulus settlement was very low, including two settlements which were the lowest in the 40-year historical time series. This led to dramatic management intervention – in 2008-09 the fishing effort was reduced by 44 percent and in 2009-10 a further 73 percent over the 2007-08 level in an attempt to maintain breed stock at a sustainable level. In 2010-11, the western rock lobster fishery moved from an effort, or input, controlled management regime, to a quota-based regime.

Other subsequent studies explored notable variations in recruitment and stock levels through the western rock lobster lifecycle and explored different management methods for ensuring sustainable future catch. A study in the early 2000s demonstrated that by 1999, egg production of the stock had increased to a 134 percent of the target level and 22 percent of the virgin level and indicated that protection of setose female lobsters was the most effective control, followed by reduction input usage and setting of a maximum legal size[58].

As a fundamental input to determining the TACC level, being able to accurately predict recruitment of adult lobsters into the fishery is of vital importance. However, in recent years there have been unexplained anomalies in modelled forecasts versus actual outcomes that have bought the efficacy of the forecasting tool into question.

The literature review has identified 22 publications reporting on research that relates primarily to the western rock lobster stock assessment system. Chronologically, these projects can be observed in three clusters (see Figure 31 below). Firstly, a significant body of work during the 1990s contributed to developing the forecasting algorithms. Immediately following the settlement anomaly discussed above, some effort went into understanding potential causes of the anomaly that is in additional to research pertaining specifically to habitat and ecology

[57] Langlois, T. (2019), 'Climate driven shifts in benthic habitat composition as a potential demographic bottleneck for Western Rock Lobster: understanding the role of recruitment habitats to better predict the undersize lobster population for fishery sustainability' University of Western Australia School of Biological Sciences, School of Agriculture and Environment and Oceans Institute

[58] Hall, N. and Chubb, C. (2001), 'The status on the Western Rock Lobster fishery and effectiveness of management controls in increasing the egg production of the stock', *Marine and Freshwater Research,* 52(8), 1657-1667

discussed in Section 0). The finally, over the course of the past five years, research has focused mainly on improving the reliability of the framework and assessing alternatives.
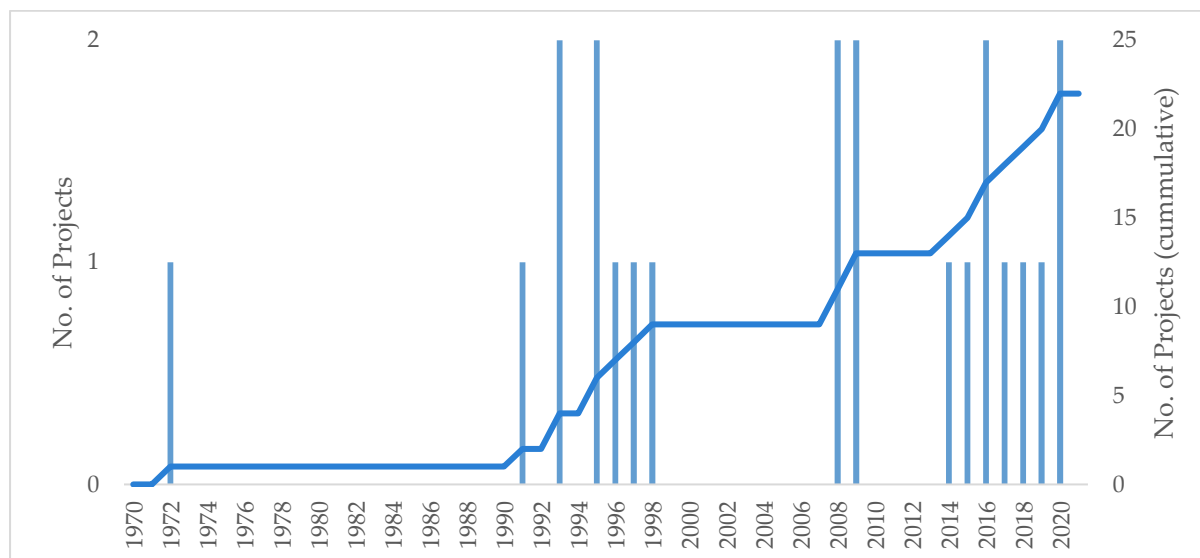
FIGURE 31 - FREQUENCY OF RESEARCH REPORTING UNDER THEME 1: PROGRAM C – CERTAINTY IN STOCK ASSESSMENTS

Overall, around half of the identified research projects have focused on aspects of improving the predictive model framework. This is illustrated in the following Figure 32. These sub-themes are further discussed in the following sub-sections.

- Understanding the anomalies
- Assessment of alternative models
- Development of surveying tools and techniques
- Predictive algorithm development
- Model validation and improvement

FIGURE 32 - MAIN TOPICS OF FOCUS OF HISTORICAL RESEARCH UNDERTAKEN UNDER THEME 1: PROGRAM C

Development of surveying tools and techniques

Several historical research projects have contributed to the development and optimisation of specific field tools that are used to facilitate the puerulus surveys that underpin the stock assessment modelling:

- In the early 1970s a tool that facilitates continuous sampling of puerulus and post-puerulus animals was developed as part of a study investigating puerulus survival and growth through to adult animals, which made sampling of puerulus stock more effective[59].

- One study exploring the effectiveness of sampling compares four pot or trap methods of sampling and two diver-based survey methods to assess relative effectiveness. The study found that overall diver-based methods were less accurate in detecting patterns of known abundance and produced inferior size-composition data. The optimal method used a mesh modified pot[60].

- Following the identification of low stock levels in shallow waters, one current study endeavours to produce accurate measures of pre-recruit abundance through the western rock lobster fishery, compare this with commercial monitoring of undersize lobster abundance and puerulus settlement data, design and construct a more efficient data recording tool to increase the accuracy and speed of data collection and develop baseline habitat descriptions at all potting locations throughout the shallow water survey area. This will also determine the relationship between sample rate required to detect different magnitudes of marine habitat change at these survey locations[61].

Predictive algorithm development

A significant body of work contributed to the development of the fundamental predictive algorithms:

- In the early 1990s, a study measured spawning stock levels for the western rock lobster.[62] By the mid 1990s, the relationship between spawning stock environment and fishing for the western rock lobster was established, demonstrating that environmental effects explain the fluctuations in puerulus settlement in the coastal sites of Dongara and Alkimos, with spawning not being significant. However, the reduction in spawning stock appears to be the main factor explaining the decline in Abrolhos Is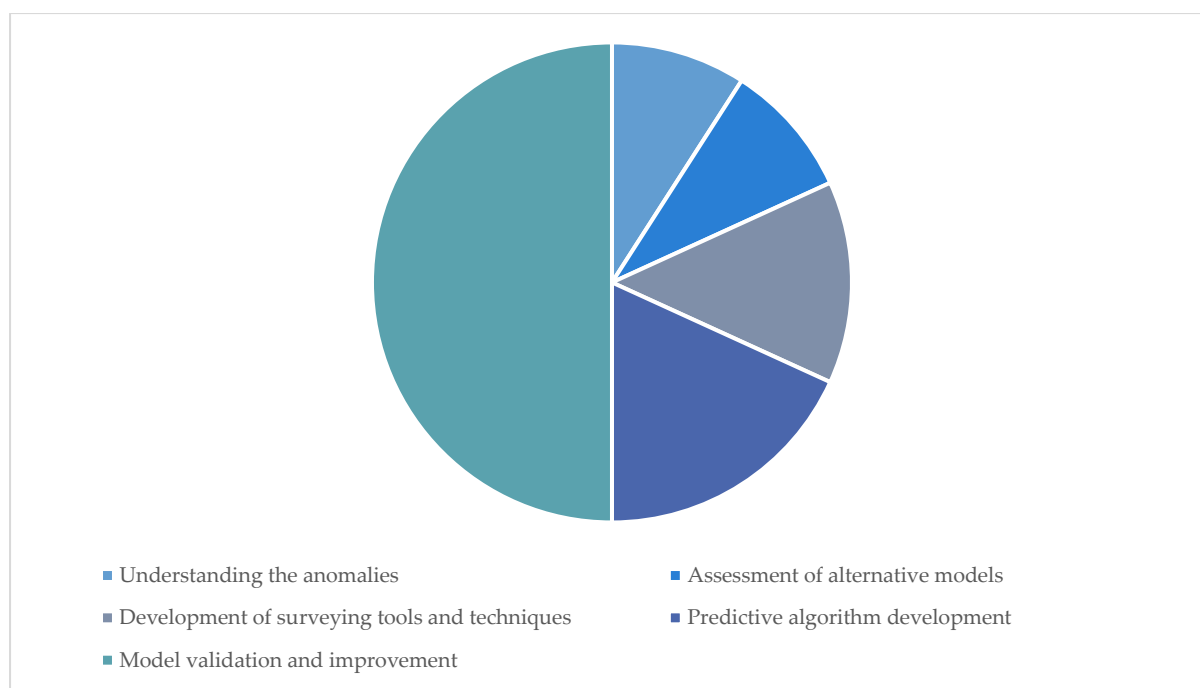land settlement during the previous nine years. The complementary relationship of recruitment to spawning stock shows that fishing effort two years prior to spawning (i.e. recruits to the fishery) is significant in explaining the decline in coastal spawning stock[63]. Other studies broadened the spatial analysis and assessed spatial variation in puerulus settlement within and across the regions to underpin a more accurate predictor of regional catches and to determine the impact of catch in northern regions on subsequent stock levels in southern regions[64].

- By the mid-1990s, this research resulted in two independent methods of predicting the catch. The first is based on an index of abundance of puerulus settling on collectors

[59] Phillips, B. (1972), 'A semi-quantitative collector of puerulus larvae of the Western Rock Lobster', *Crustaceana,* 22(2), 147-154

[60] Tuffley, E., de Lestang, S., How, J. and Langlois, T. (2018) 'Methodological comparison for sampling populations of commercially important rock lobster species', Bulletin of Marine Science – Miami, 94(3)

[61] De Lestange, S. (2019), 'Developing an independent shallow-water survey for the Western Rock Lobster fishery: tracking pre-recruitment abundance and habitat change', *Western Australian Government Department of Primary Industries and Regional Development*

[62] Chubb, C. (1991), 'Measurement of spawning levels for the Western Rock Lobster', *Revista de Investigaciones Marinas,* 12, 223-233

[63] Caputi, N., Chubb, C. and Brown, R. (1995), 'Relationship between spawning stock environment and fishing effort for the Western Rock Lobster', *Crustaceana,* 68(2), 213-226

[64] Caputi, N., Brown, R. and Chubb, C. (1993), 'Regional prediction of the Western Rock Lobster Commercial Catch in Western Australia', *Crustacean,* 68(2), 245-256

made of artificial seaweed placed at two locations since 1969 and checked on a monthly basis. The second method is based on an index of abundance of juveniles, which is obtained using catch rates of undersized lobsters from a monitoring programme conducted onboard commercial fishing vessels. Indices of puerulus and juvenile abundance have been used in a multiple regression analysis to obtain a multiple correlation of 0.95 with catch and provide accurate predictions of catches. Separate predictions have been determined for the migratory (November to January) and non-migratory (February to June) phases of the fishery. The pueulus and juvenile indices complement each other, with the puerulus providing a up to four year indication of the likely trends in catch, while the juvenile index provides a more accurate prediction of the catch a year in advance[65].

Understanding anomalies

Several research projects endeavoured to better understand possible causes of the recent anomalies. In 2008 lower than expected puerulus settlement was observed, representing a departure from the long-standing relationship between environmental variables and corresponded with anecdotal information that there appeared to be a reduction in the colonisation of the collectors by other invertebrates such as shrimps and crabs.

- Earlier studies demonstrated that environmental factors such as the Leeuwin Current and westerly winds have significant effect on levels of western rock lobster puerulus settlement at coastal locations. However, these environmental factors do not explain an average decrease of 50 percent in the puerulus settlement at the Abrolhos Islands from the 1970s compared to that observed in the early 1980s.

- Other studies responded to understanding observed changes in recruitment. One study explored potential environmental causes of observed reduced colonisation on western rock lobster puerulus collectors by a wide range of species[66].

- A later study used a larval advection model and the rock lobster population dynamics model to assess the effect of the spatial distribution of the breeding stock on puerulus settlement. It assessed environmental factors such as water temperature, current, wind, productivity and eddies on breeding stock and peurulus settlement and examined climate change trends of key environmental parameters and their effect on the western rock lobster fishery. The study concluded that breeding stock at all locations along the Western Australian coast is likely to be important to settlement and that the environmental factors that influence puerulus settlement may be influenced by climate change[67].

Model validation and improvement

Ongoing research is designed to further validate and improve the forecasting model:

[65] Caputi, N., Brown, R. and Phillips. (1993), 'Predicting catches of the Western Rock Lobster based on indices of puerulus and juvenile abundance', *ICES Marine Science Symposia,* 199, 287-293

[66] De Lestang, S., How, J. and Foster, S. (2008), 'Assessing possible causes behind the reduced colonisation of Western Rock Lobster Puerulus collectors by a wide suite of species' *Fisheries Research Report No. 218,* Government of Western Australia Department of Fisheries

[67] Caputi, N., Feng, M., de Lestange, S., Denham, A., Penn, J., Slawinski, D., Pearce, A., Weller, E. and How, J. (2009), 'Identifying factors affecting the low Western Rock Lobster puerulus settlement in recent years', *Fisheries Research Report No. 255,* Government of Western Australia Department of Fisheries

- **Improvements in data** – some studies endeavoured to further validate spawning stock indices derived from commercial fishing data and to better understand migration between the zones[68]. Subsequent studies also endeavoured to improve the systems deployed to provide data to the stock prediction analysis including studies aimed at understanding the impact of different tagging technologies on animal health[69] and potential use of lipofuscin age pigment as a tool for age determination of western rock lobster[70].

- **Accuracy of prediction models -** studies designed to improve the accuracy of the prediction models have also been undertaken. One study determined the relative contribution of larval production from different areas to the abundance and spatial distribution of puerulus settlement over 15 years using a larval advection model, with the results having implications for the management response to the fishery[71].

- **Post-peurulus settlement -** fisherman also observed changes in catch patterns that suggest that post-puerulus settlement had shifted to deep water. A study was designed to assess whether this is the case and to establish new techniques for conducting future research into post-puerulus settlement to address uncertainty around the poor peurulus settlement[72].

- **Replacement of empirical catch rate indices -** when the industry changed to a quota-based framework, previous empirical catch rate indices became problematic. One study implemented a tag-recapture programme to determine spatially specific exploitation rates and legal biomass levels, increase precision of estimates for movement rates between management zones and improve understanding of the variability of growth throughout the range of the fishery[73].

- **Spawning variation with environmental factors -** a study into causes of consecutive years of low puerulus settlement concluded that over 70 percent of the variation in peurulus settlement is explained by the timing of spawning, storm activity during autumn and spring and offshore water temperatures during February. The study also concluded that further verification based on additional longitudinal data is required and that climate change may affect these environmental factors and their impact on the sustainability of the western rock lobster fishery[74].

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[68] Melville-Smith, R. (1996), 'Fishery's independent survey and migration of the Western Rock Lobster',

[69] Melville-Smith, R. and Chubb, C. (1997) 'Comparison of dorsal versus ventral tag retention in Western Rock Lobster', *Marine and Freshwater Research CSIRO Publishing,* 48(7), 577-580

[70] Sheehy, M., Caputi, N., Chubb, C. and Belchier, M. (1998), 'Use of lipofuscin for resolving cohorts of Western Rock Lobster', *Canadian Journal of Fisheries and Aquatic Sciences,* 55(4), 925-936

[71] Caputi, N., Feng, M., Penn, J., Slawinski, D., de Lestang, S., Weller, E. and Pearce, A. (2008), 'Evaluating source-sink relationships of the Western Rock Lobster fishery using oceanographic modelling' *Fisheries Research Report No. 209,* Government of Western Australia Department of Fisheries

[72] Winzer, A., de Lestang, S. and Melville-Smith, R. (2009), 'Pilot phase trial to quantify the extent and relevance of any deep water puerulus settlement that may have taken place in the Western Rock Lobster fishery', *Western Rock Lobster Council*, Fisheries Research and Development Corporation

[73] How, J. (2014), 'An industry-based mark recapture program to provide stock assessment inputs for the Western Rock Lobster Fishery following introduction of quota management', *Western Australian Government Department of Primary Industries and Regional Development*

[74] De Lestang, S., Caputi, N., Feng, M., Denham, A., Penn, J., Slawinski, D., Pearce, A. and How, J. (2015), 'What caused seven consecutive years of low puerulus settlement in the Western Rock Lobster fishery of Western Australia', *ICES Journal of Marine Science,* 72(July), 59-58

- **Variation in trap catchability -** previous analysis identified that stock projections and Maximum Economic Yield determinations are sensitive to assumptions associated with the catchability of western rock lobster during breeding stock surveys. One current study endeavoured to determine environmental and biological causes of variation in trap catchability, quantify the relationship between these factors and catchability and standardise the empirical indices used for western rock lobster stock assessments for effects of catchability[75].

- **Shallow water catch rates -** a recent focus has been on observed anomalous low western rock lobster catch rates in shallow waters. One current study is endeavouring to determine the spatial extent and temporal trends in regions exhibiting abnormally low legal catch rates throughout the western rock lobster fishery, identify lobster life stages resulting in low legal catch rates in the main areas exhibiting low catch levels, examine factors that may be causing the low rates and identify the implications of low catch regions to stock assessment[76]. Another is doing further work on improving shallow water stock assessment[77].

- **Efficiency of model -** Another current project is seeking to simplify and make the operations of the stock assessment model more efficient[78].

Assessment of alternative models

Several alternative assessment models have been explored. Studies have endeavoured to apply a conventional fisheries model to describe the relationship between recreational and commercial catches as an alternative to the current empirical and statistical models as a tool for integrated fisheries management[79].

Another study also examined similarities and differences between the biological characteristics of different species of Australian lobster and the data collection and stock assessment methods used for those different species[80].

Theme 2: Better informed TACC decisions

In accordance with the *Fisheries Resources Management Act 1994* (WA) the ultimate decision on Total Allowable Commercial Catch (TACC) is made by the responsible minister on advice from DPIRD and the TACC Committee via the Western Rock Lobster Board. In the case of future regulation under the *Aquatic Resource Management Act 2016* (WA), the responsibility shifts to the DPIRD CEO. However, in both cases, the decision and advice is significantly influenced by

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[75] DPIRD (2016), 'Determining variation in catchability of Western Rock Lobsters to standardise important abundance indices used for stock assessment', *Western Rock Lobster Council*

[76] Langlois, T. (2016)'Assess causes and implications of anomalous low lobster catch rates in the shallow water areas near the centre of the Western Rock Lobster fishery', The University of Western Australia

[77] DPIRD (2020) 'Develop and undertake fishery-independent shallow water survey project'

[78] DPIRD (2020), 'Finalise updated West Coast Rock Lobster Harvest Strategy and Control Rules' Fisheries Management Paper No. 264, Western Australian Department of Primary Industries and Regional Development

[79] (2005), 'A preliminary study of the dynamics of recreational fishing in the Western Rock Lobster fishery for use in integrated fisheries management'

[80] Plaganyi, E., McGarvey, R., Gardner, C., Caputi, N., Dennis, D., de Lestang, S., Hartmann, K., Liggins, G., Linnane, A., Ingrid, E., Aldridge, B., Green, B. and Villanueva, C. (2017), 'Overview, opportunities and outlook for Australian spiny lobster fisheries', Reviews in Fish Biology and Fisheries, 28, 57-87

the outcomes of modelling to determine both the Maximum Sustainable Yield (MSY) and Maximum Economic Yield (MEY).

MSY refers to the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions. Whereas MEY occurs when the amounts of catch and effort in a fishery are sustainable and profit-optimising.

For the following reasons, in most fisheries, particularly high value fisheries, MEY is the preferred method for setting the TACC:

- **Maximises fishery profits** – provided the MEY model is robust and its inputs are reliable, TACC set in accordance with the MEY will maximise profits irrespective of changes the price of the target catch or the cost of fishing. This not only maximises returns for fishers, but in most cases improves international competitiveness and builds in resilience to economic shocks.

- **Optimal resource conservation** – in most cases catch will be less under MEY compared to MSY, resulting in a larger conserved stock of the natural resource.

- **Improved resource allocation** – when used in conjunction with the right mechanism for allocating the natural resource (such as individual tradable quota), TACC set against MEY mitigates over-capitalisation and expensive structural adjustment programs.[81]

In the first instance, both MSY and MEY modelling for western rock lobster requires competent input from the stock assessment modelling discussed in Theme 1, Program C. However, particularly in the case of MEY, the reliability of what is a more complex model and certainty around the inputs to the MEY modelling is of critical importance. This is reflected in the historical research supporting MSY and MEY, whereby six of the seven identified relevant publications focus on MEY.

As seen in Figure 33, below, the literature review has identified only six research projects identified within Theme 2 since 2005.
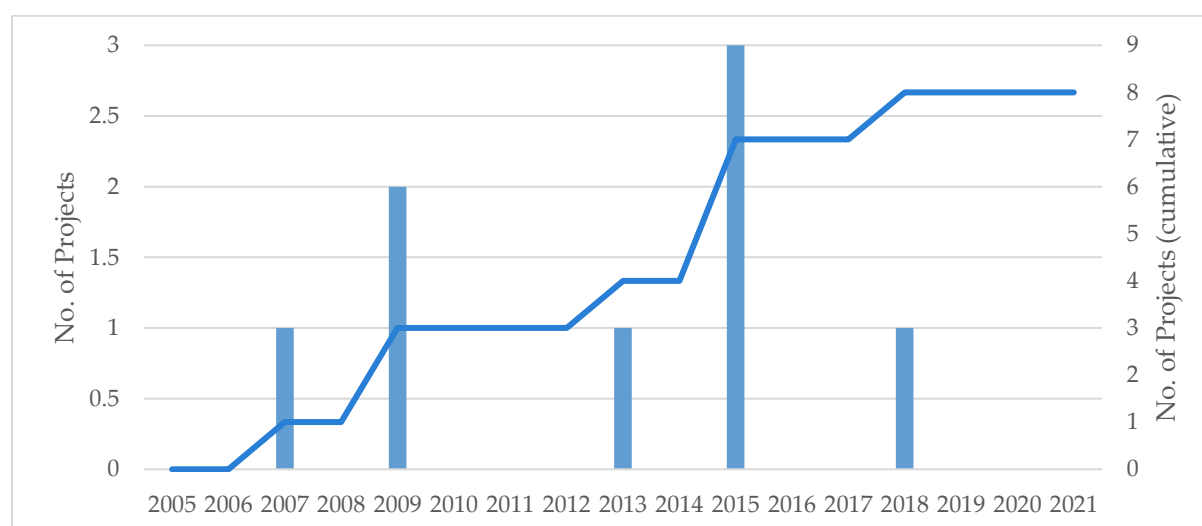

FIGURE 33 – FREQUENCY OF RESEARCH REPORTING UNDER THEME 2

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[81] Kompas, T., Grafton, Q., Che, N., Chu, L. and Hilborn, R., *The Importance of Maximum Economic Yield in Fisheries Management',* Crawford School of Economics and Government, Australian National University

As seen in Figure 34, a majority of the historical research undertaken falls within Program B – Maximum Economic Yield (MEY) Modelling.
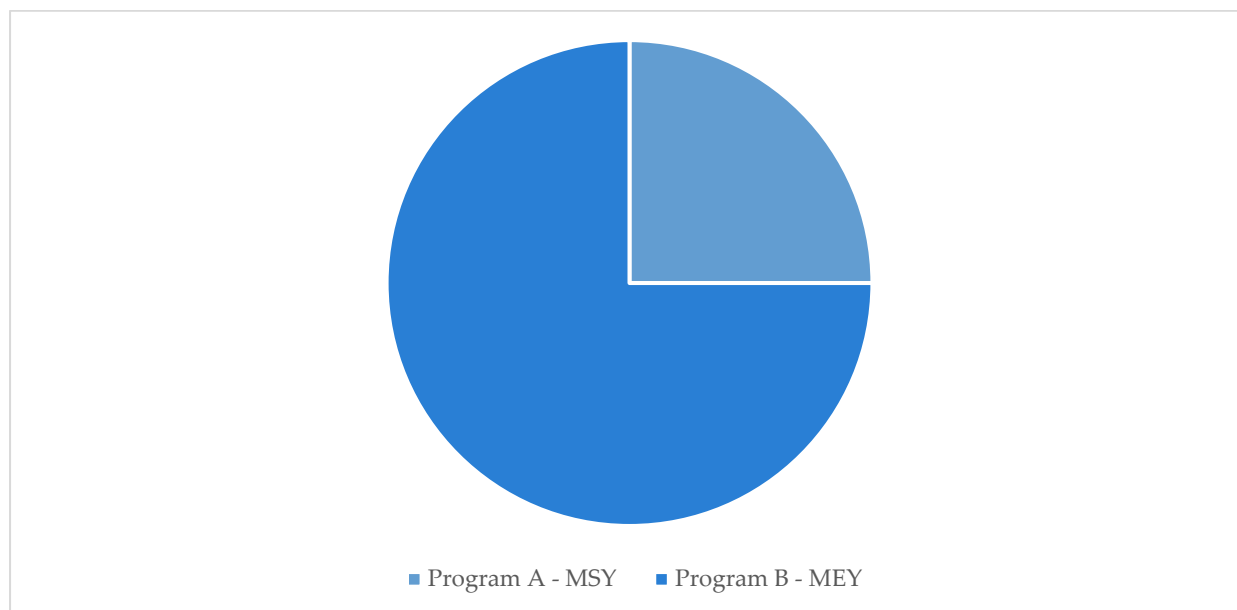

FIGURE 34 – MAIN TOPICS OF FOCUS OF HISTORICAL RESEARCH UNDERTAKEN UNDER THEME 2

Program A: Maximum Sustainable Yield (MSY) Modelling

Research supporting the optimal effectiveness of the Maximum Sustainable Yield (MSY) model used to support TACC decisions appears to be limited. A single project that reported in 2009 assessed current data sources and their potential for estimating harvest rates and increases in efficiency in the fishery using change in ratio and index removal techniques, evaluated whether additional sources of information are needed to produce more robust estimates of harvest rate and efficiency increase and assess whether the estimates of harvest rate and fishing efficiency are reliable[82].

A more recent study in 2015 compared the Western Rock Lobster fishery pre and post-2010 to compare the operate of the fishery under the two alternative control systems – total allowable effort with individual transferrable units to operate close to MSY, and a total allowable catch management system that targets MEY. This study compared lobster stocks and overall industry economic performance as well as the value of commercial fishing rights.[83]

Program B: Maximum Economic Yield (MEY) Modelling

Setting TACC based on Maximum Economic Yield (MEY) was first considered in the context of an industry that had been facing significant economic pressure from increasing costs, lower prices and predicted lower catch. The changes that occurred in 2008-09 and 2009-10 (see Theme 1, Section B) provided an opportunity to assess the opportunity for setting TACC based

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[82] De Lestang, S., Hoenig, J., Frusher, S. and Hall, N (2009) 'Evaluating the potential use of change-in-ratio and index removal techniques for determining harvest rates and efficiency increases in the Western Rock Lobster fishery', *Fisheries Research Report No. 234*, Western Australian Government Department of Primary Industries and Regional Development

[83] Penn, J., Caputi, N., de Lestang, S. (2015). 'A review of lobster fishery management: the Western Australian fishery for *Panulirus cygnus,* a case study in the development and implementation of input and output-based management systems.

on MEY. As a result of these events vessel numbers declined by 14 percent and 36 percent in 2008-09 and 2009-10 respectively compared to 2007-08 and fishery profit increased by $13 and 49 million for 2008-09 and 2009-10 respectively.

The following historical studies and evaluations of MEY have been undertaken:

- **Economic efficiency of MEY –** several studies have assessed the economic efficiency of MEY under various systems:
    - In 2007, a study explored improving economic efficiency through detailed review of input controls over the western rock lobster fishery[84].
    - Following on from this, another study assessed the use of MEY assessment in the light of the introduction of quota-based management in the 2010-11 fishing season. The study assessed the use of decision-rule framework for the management of the fishery and as an important input to setting TACC each year[85].
    - Another study assessed and demonstrated the economic benefits of fishing at levels close to those estimated by MEY modelling under an input management regime[86].

- **MEY under effort and quota controls -** a later study compared MEY assessment under effort and quota controls. The shift to a quota-based management framework resulted in changes in fishing practice leading to reduction in costs and an increase in lobster prices (which coincided with the development of the lucrative PRC live market), providing an opportunity to assess MEY under an effort and quota control management framework. This demonstrated that the MEY level of fishing has increased egg production to well above threshold levels that were based on MSY, providing the fishery with increased resilience when faced with environmental perturbations. This in turn, enables consideration for relaxing some biological controls such setose females, females above a maximum size and lobsters with carapace length between 76mm and 77mm, the relaxation of which could increase profits by around $15 million per annum as the result of higher catch rates and reduced fishing effort[87].

- **Adopting MEY -** The most recent study developed generally accepted methods for setting the annual TACC with consideration for MEY analysis, changing price relationships in the market, known risk factors, future catch, biomass and limits on harvest rates[88].

- **Triple bottom line assessments –** in 2018 a study was conducted that used the Western Rock Lobster fishery as a hypothetical case study for an Ecosystem-based fisheries

[84] Wizner, A. (2007), 'Improving economic efficiency through detailed review of input controls in the Western Rock Lobster fishery' Fisheries Research and Development Corporation

[85] Caputi, N., de Lestang, S., Reid, C., Hesp, A., How, J. and Stephenson, P. (2009) 'Decision-support tools for economic optimisation of Western Rock Lobster', *Fisheries Research Report No. 257,* Western Australian Government Department of Primary Industries and Regional Development

[86] Reid, C., Caputi, N., de Lestang, S. and Stephenson, P. (2013) 'Assessing the effects of moving to maximum economic yield effort level in the Western Rock Lobster fishery of Western Australia', Marine Policy, 39, 303-313

[87] Caputi, N., de Lestang, S., Reid, C. and Hesp, A. (2015) 'Maximum economic yield of the Western Rock Lobster fishery of Western Australia after moving from effort to quota control', *Marine Policy,* 51, 452-464

[88] Rogers, P., de Lestang, S., How, J., Caputi, N., McLeod, P., Harrison, N. and McMath, J. (2015) 'Establishing a low risk incremental approach for setting Total Allowable Commercial Catch in the Western Rock Lobster Fishery, taking into account maximum economic yield and other industry objectives', Fisheries Research and Development Corporation

management (EBFM) or 'triple bottom line' approach to resource management. This study assessed how the move from MSY to MEY in 2010 affected each of the ten EBFM criteria related to social, economic and ecological factors[89].

Theme 3: Enhancing fishing operations

Broadly, research and development in the area of fishing operations has two key objectives:

- **Improving productivity** - as with all primary industries, the western rock lobster industry must continue to improve productivity to ensure that profitability levels are at least maintained and that its products' market share is resilient in adversarial market conditions.

- **Minimisation of negative externalities** - fishing operations are at the coal-face of the interaction between the western rock lobster industry and the natural environment. Minimising that impact is fundamental to both the sustainability of the resource and social license to operate.

Theme 3 focuses on the aspects of fishing operations that pertain to productivity, including factors that impact on operational efficiency and safety. Managing the environmental impacts of the western rock lobster fishing effort is addressed under Theme 5 in Program A.

A specific challenge with leading research in this area is that the development of technology that leads to business improvement is typically the domain of the private sector, whereby services and systems suppliers develop products that they sell to businesses on commercial terms. As such, the focus of research undertaken in accordance with this Theme 3 will focus on:

- **Pre-competitive space** – where the development of new knowledge will reasonably be expected to be taken on by existing or new commercial service providers to deliver the required tool to industry or to improve an existing tool.

- **Market failure** – where the private sector does not and is unlikely to develop knowledge or deliver a tool that industry has determined to be important.

As seen in Figure 35, there have been a total of 16 historical and current research projects undertaken within Theme 3. A total of 5 of these, almost one third of all projects, commenced in 2020.

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[89] Caputi, N., de Lestang, S., How, J., Trinnie, F., and Fletcher, W. (2018). 'Ecosystem-based fisheries management (or 'triple bottom line') assessments of the western rock lobster resource: is there an optimal target for fishing?' Western Australian Department of Primary Industries and Regional Development.
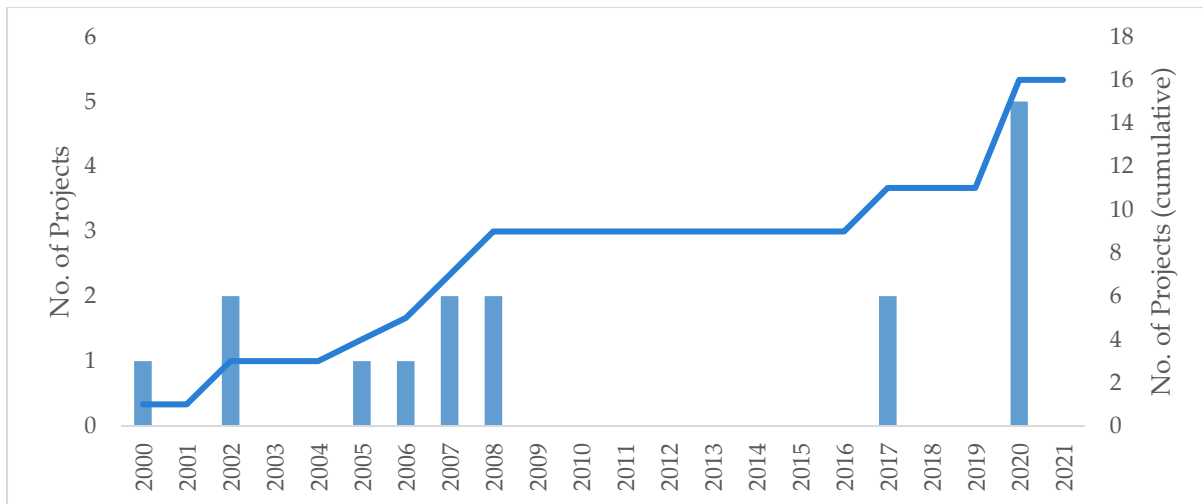
FIGURE 35 – FREQUENCY OF RESEARCH REPORTING UNDER THEME 3

Additionally, as seen in Figure 36, Program A – Digitisation of Industry Information Systems and Program D – Fishing Operations account for a majority of the historical and current research projects. Both of these programs have multiple current projects that commenced in 2020 indicating the recent relevance with changing industry dynamics.

- Program A - Digitisation of Industry Information Systems
- Program B - Occupational Health and Safety
- Program C - Workforce
- Program D - Fishing Operations
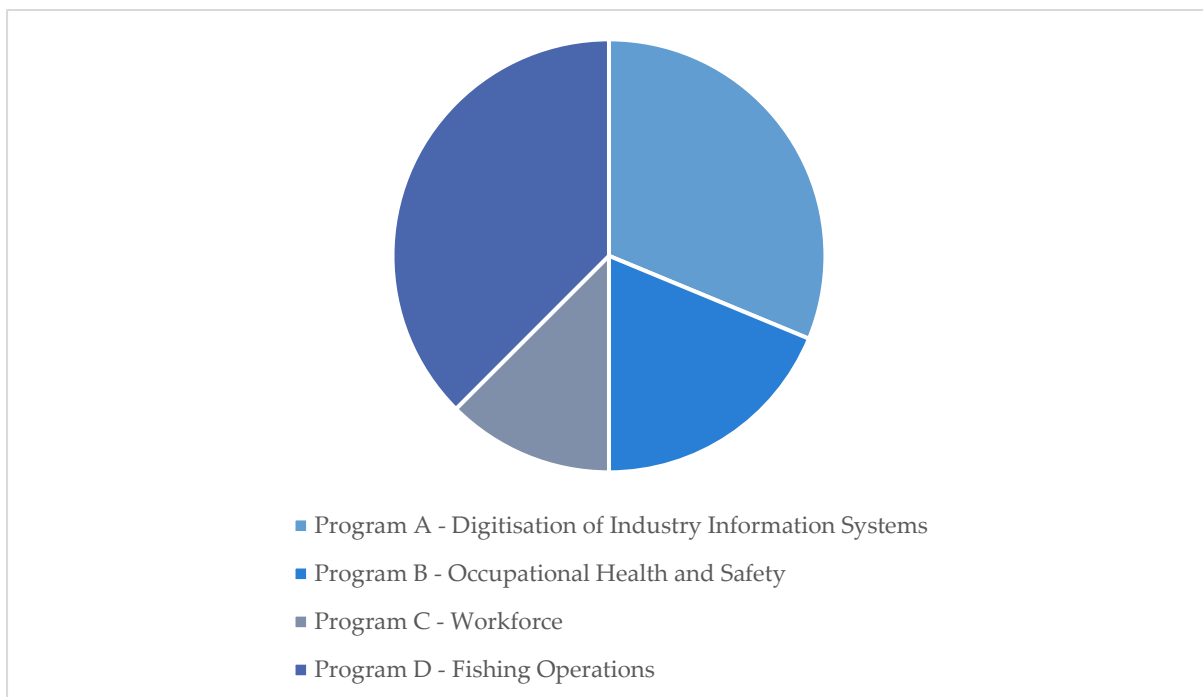
FIGURE 36 – MAIN TOPICS OF FOCUS OF HISTORICAL RESEARCH UNDERTAKEN UNDER THEME 3

Program A: Digitisation of industry information systems

The application of digital technology to all aspects of operations typically delivers two broad benefits to industry and the businesses that comprise those industries:

- **Cost reduction** – because digital systems effectively automate many information-based processes and substantially mitigate scope for human error, generally speaking they result in more efficient and reliable business systems.

- **Information rich decision-making** – because digitised business systems produce and store large amounts of data across temporal and spatial dimensions that can be integrated and integrated with external datasets and analysed, providing a platform for decision-support tools across many aspects of industry, along the supply chain and within individual businesses.

Collectively, these two aspects of digitised business systems can deliver substantive productivity improvements at an industry and enterprise level.

With respect to the digitisation of business systems, the western rock lobster industry substantially lags behind many other sectors, including other primary industry sectors. Opportunities for improving the efficiency of business sectors and providing access to existing datasets for enhanced strategic and tactical decision-making at both an enterprise and industry level are significant and include:

- Digitisation of the licensing system
- Real time quota trading platforms
- Onboard fishing and OHS monitoring and audit systems
- Supply-chain traceability
- Data aggregation and decision-making tools.

While historical research in this area has been limited, several new projects are currently underway. To date, research in this area has focused on:

- **Fishing decision support tools** - in 2017, via the establishment of a coast radar system, a webapp for fisherman was developed that offers predictive warning for ocean conditions that can improve efficiency and reduce the loss of fishing gear, as well as contributing to improved general understanding of water circulation and puerulus settlement rates[90] that is the subject of Theme 1.

- **Resource management decision support tools** - in the same year a study was undertaken to scope national and international data collection and analysis innovation to assist with policy development and fisheries management, develop and extend a fully digitised database to achieve at least three management objectives and expand the database to meet non-management objectives[91]. In 2020, a new project endeavours to build on existing underwater imaging that is currently used to monitor abundance of lobster and their biodiversity by developing an automated lobster detection system for these images using deep learning techniques. The resulting prototype is understood to be the first automated lobster detection technique for partially and occluded lobsters[92].

- **Digitisation of DPIRD administrative systems** - DPIRD has also invested in the digitisation of its systems and processes in the areas of research data collection[93] and processing of processor returns[94].

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[90] Pattiaratchi, C., Langlois, T., de Lestang, S. and Cosoli, S.(2017) 'Develop a strong current warning system and inform knowledge of the nearshore current regime', Oceans Institute, University of Western Australia.

[91] Taylor, M. (2017), 'Digitising the Western Rock Lobster Industry',

[92] Mahmood, A., Bennamoun, M., An, S., Sohel, F., Boussaid, F., Hovey, R. and Kendrick, G. (2020) 'Automatic detection of Western Rock Lobster using synthetic data', *ICES Journal of Marine Science, 77*(4), 1308-1317

[93] DPIRD (2020) 'Implement research e-monitoring tools for data collection'

[94] DPIRD (2020) 'Develop electronic processors returns'

Program B: Occupational Health and Safety

In addition to the obvious humanity and wellbeing aspects, Occupational Health and Safety (OHS) is fundamental to productivity, license and ability to operate. Poor OHS standards and incidents result in lower labour productivity, challenges in attracting an effective workforce and constrained social license to operate. Furthermore, the absence of strong and defendable OHS management frameworks in the context of new Western Australian workforce laws will expose the western rock lobster industry to the prospect of litigation and subsequent business failure.

Research in this area commenced in the early 2000's and focused on both fishing and processing operations OHS:

- **Processing sector OHS -** in 2002 a code of practice was developed for handling lobster with respect to food safety and OHS[95]. A comprehensive set of OHS guidelines tailored for each State and Territory jurisdiction's legislative framework and industry specific issues was also developed[96].

- **Fishing operations OHS -** related to this a separate project involved the design and testing of an assessment tool to evaluate the uptake of the WAFIC Occupational Health and Safety Code in the western rock lobster industry, demonstrate the benefits of such a tool to the Western Australian commercial fishing industry for wider application across the nation and to demonstrate to various state and national peak bodies the benefits of the tool as part of the national seafood OHS extension program[97].

Program C: Workforce

The ongoing productivity and profitability of the western rock lobster industry is critically dependent on having access to an adequate number of suitably trained skilled and semi-skilled workers. Like many regionally-oriented industries, attracting and sustaining the workforce is challenging, especially through periods characterised by resources sector expansion. This is because workers with maritime skills are keenly sought after by the State's significant resources industry, who offer wage premiums, particularly during expansionary phases.

Historical projects in this area have been development projects, focusing on attracting workers to the industry. In 2007 the Western Rock Lobster Council undertook a project designed to re-launch its website with a view to increasing access to job position advertisements, placement of crew with fishers seeking employees, providing opportunities for training and employment agencies to network with the fishing industry for employment purposes and to identify the potential for using the functionality as a template for online employment facilitation across the wider fishing industry. Whilst the site was launched, it was not as successful in placing skilled workers in the western rock lobster industry as anticipated[98].

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[95] Richards, S. (2002) *A code of practice for handling rock lobster,* Western Australian Fishing Industry Council

[96] WAFIC (2002) 'Occupational health and safety national extension strategy',

[97] WAFIC (2005) 'A pilot project conducted in the Western Rock Lobster industry to create a software audit tool for assessing occupational health and safety compliance with industry best practice on board a commercial fishing vessel'

[98] Western Rock Lobster Council (2007) 'Further development of an employment web page for the Western Rock Lobster industry', Fisheries Research and Development Corporation

The only other identified investment in workforce issues was a project undertaken around the same time that focused on developing leadership skills in the industry.[99]

Program D: Fishing systems

A fundamental driver of business productivity is innovation that results in more efficient and effective systems at the most basic level of the industry – catching western rock lobster. Historical research in this area has focused on:

- **Bait** - bait is a significant input to the western rock lobster fishing exercise and therefore bait productivity is a key driver of profitability. In the 1990s and early 2000, much of the bait used by the western rock lobster industry was imported, presenting potential supply risk to the industry.
  - A study undertaken at the turn of the century contributed toward the development of an efficacious and cost-effective artificial bait for western rock lobster as an option for mitigating imported bait access risk by identifying compounds in natural baits preferred by western rock lobster that contribute to locomotion of lobsters[100].
  - Developing means of saving on bait usage without reducing catch was the subject of one study that estimated that fisherman could reduce their bait usage by approximately 40 percent from commonly used levels without reducing catch-rate and that a redesigned and more efficient bait saver could potentially reduce bait usage by as much as 90 percent[101].
  - A recently commissioned project is further assessing bait usage in the industry as a component research required to maintain MSC accreditation for the industry[102].

- **Pot design** – Another major driver of fishing cost is the number of pot lifts required to achieve the catch – estimated to contribute around $60 million per annum to total industry costs.
  - One study that trialled various new pot designs indicates that designs can be developed that result in more efficient catch, therefore reducing the number of pot lifts required[103].
  - A subsequent study assessed the possible cost savings that arise from the use of a reduced number of more efficient pots (traps), combined with modified fishing processes that reduce the number of pot lifts. The study explored the extent to which use of the modified pots (traps) may alter fishing systems away from the 24 hours soak times toward soak times that reach out to 48 to 72 hours[104].
  - A recently commissioned project is reviewing new potential pot designs[105]

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[99] Geraldton Fishermen's Cooperative (2008) 'FRDC emerging leader governance scholarship', Fisheries Research and Development Corporation

[100] Chisalberti, E., Chubb, C., Park, J. and Glendenning, L. (2000), 'Chemoattraction and the development of an artificial bait for Western Rock Lobster', Fisheries Research and Development Corporation

[101] (2007) 'Development of bait saving strategies for the Western Rock Lobster fishery', Fisheries Research and Development Corporation

[102] DPIRD (2020) 'Address MSC P2 condition on bait usage'

[103] Western Rock Lobster Council (2007) 'Increased economic efficiency for the Western Rock Lobster fishery through improved pot design', Fisheries Research and Development Corporation

[104] Western Rock Lobster Council (2008) 'Improving profitability in the Western Rock Lobster fishery using a rock lobster trap', Fisheries Research and Development Corporation

[105] DPIRD (2020) 'Review of new rock lobster pot design'

Theme 4: Evidence-based policy, industry and market intelligence

The two most significant threats that have faced the western rock lobster industry in recent times have not been of an ecological or operational nature, but rather of an economic, political and legal nature. These are the attempt by the Western Australian Government to unilaterally increase and nationalise a significant part of the quota and denial of access to the PRC market. Additionally, the western rock lobster industry is currently navigating some internal structural change that will influence strategic and investment decisions made by fishers, processors and other key stakeholders.

A resilient industry requires access to economic, legal, industry and market data and analysis that enables it to take proactive and pre-emptive decisions to manage political and market disruption and understand and respond to industry changes. Industry needs to be able to mount evidence-based arguments in advocacy, make informed decisions about pre-emptive actions to prevent market disruption and make informed decisions that are consistent with trends in industry structure.

As seen in Figure 37 below, 8 historical research projects have been undertaken within Theme 4. A majority of these have commenced within the past 5 years.
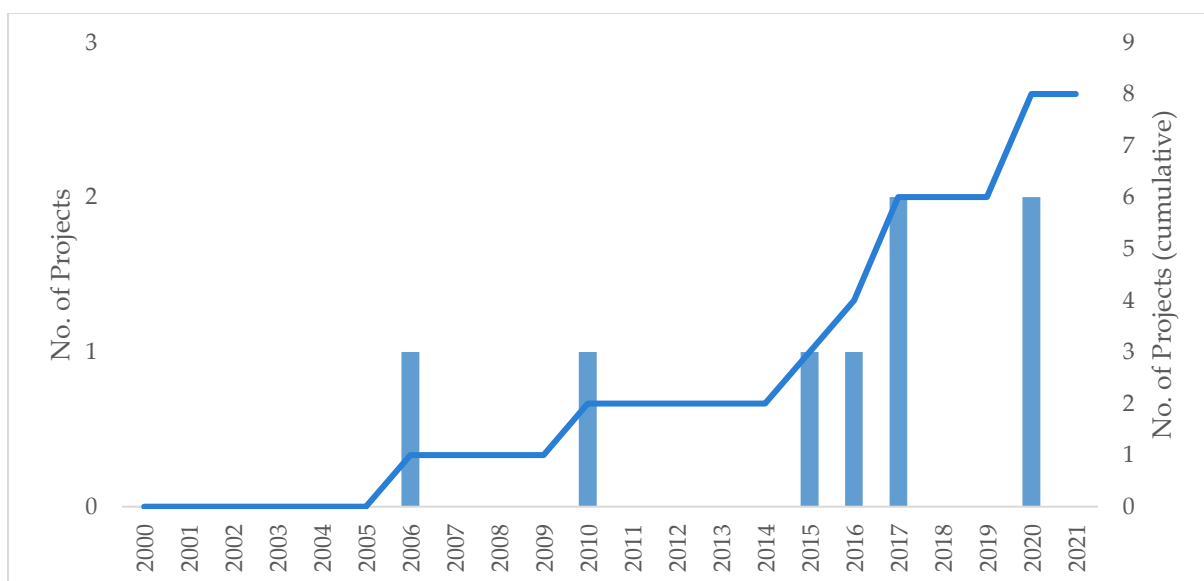

FIGURE 37 – FREQUENCY OF RESEARCH REPORTING UNDER THEME 4

As observed in Figure 38, half of historical research undertaken in Theme 4 is centred around market access intelligence discussed under Program D. Two of the four projects were commenced in 2020. Following this, the next most prominent program is Program B – Quota Frameworks.
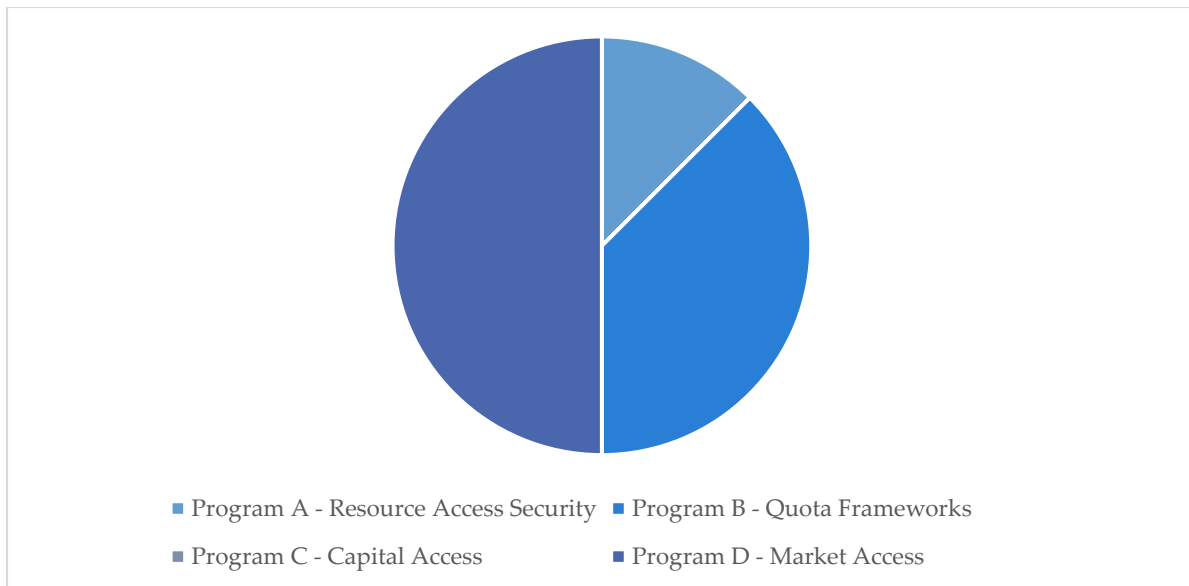
FIGURE 38 - MAIN TOPICS OF FOCUS OF HISTORICAL RESEARCH UNDERTAKEN UNDER THEME 4

Program A: Resource access security

Certainty regarding the ability to adequately access the natural resource on which the industry depends is, obviously, of paramount importance to the western rock lobster industry. Despite the relative strength of commercial fishing rights being founded in significant legal precedence dating back to the *Magna Carta* and reinforced through Australian jurisprudence and various public inquiries, commercial fishing rights continue to be undermined by Australian governments.

In Western Australia there has been a clear 'creep' of uncompensated encroachment on commercial fishing rights, culminating in the extraordinary attempt by the Western Australian Government to nationalise commercial western rock lobster quota in 2018. While industry advocacy was successful in preventing the implementation of this policy and the Western Rock Lobster Council (and previously Fishing Families WA) has made some progress for advocating for changes to the *Aquatic Resource Management Act 2016* (WA) that will give effect to greater resource access security, the threat of encroachment on commercial fishing rights remains a live issue.

To date, research on this issue has been limited to a single study commissioned by the Western Rock Lobster Council and co-funded with the WA Fishing Industry Council. It was provided as a key component of the industry's submission to the Western Australian Parliament Legislative Council Inquiry into Private Property Rights. It details the economic and legal case for more secure resource access rights for the Western Australia commercial fishing industry, including the western rock lobster industry[106].

Program B: Quota frameworks

It is widely recognised that fishery resource management is most efficient under systems whereby the total allowable catch is set on the basis of maximum sustainable or maximum economic yield that is based on sound scientific evidence and the total allowable catch is

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[106] Australian Venture Consultants (2020) *Secure fishery resource access rights in Western Australia: Policy Position Paper,* Western Rock Lobster Council

then allocated in accordance with a system based on Individual Transferrable Quota (ITQ). This ensures that the natural resource is ultimately protected and that market mechanisms efficiently allocate the harvestable resource.

Given that this is the current system for managing the commercial western rock lobster natural resource, it is not surprising that the development and optimisation of an ITQ process has been a significant focus of historical research:

- **Case for transitioning to ITQ** - to inform industry on the benefits of moving to a quota-based management regime, a study was commissioned in 2010 that outlined to fishers and other stakeholders the opportunities presented by moving to the western rock lobster ITQ framework. Benefits identified by this study included additional revenue of $80 million per annum, safer workplace and greater workforce retention[107].

- **ITQ frameworks for non-commercial objectives** - With the pending part proclamation of the *Aquatic Resources Management Act 2016* (WA), a study was commissioned to evaluate the effectiveness of a range of management arrangements including those for resource access and re-allocation, at achieving social and economic objectives, including ITQ[108].

- **Ongoing management reviews** - Consistent with the requirements of the *Fisheries Resource Management Act 1994* (WA) a review of the current harvest strategy is currently underway to support management decisions, primarily setting the TACC and for the purposes of future MSC assessments[109].

Program C: Capital access

For many western rock lobster fishers, access to particularly debt finance is critical to fund the purchase of capital equipment, quota and working capital in what is cyclical industry. For many this involves financing cash requirements using financial instruments (including with commercial banks) where collateral is a fisher's quota. Recent threats to the security of fishing rights significantly threaten capital access for the western rock lobster industry.

To date, no research has been undertaken that directly addresses the issue of access to capital for the western rock lobster industry. While progress in resource access security will perform a key role in ensuring capital access, other initiatives can be undertaken to provide the financing sector with greater confidence and ability to finance western rock lobster businesses.

Program D: Market access

Most research and innovation that pertains to markets for western rock lobster is undertaken by private organisations on a commercial and competitive basis. As such, historical research in this area has been limited and somewhat generic in its nature.

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[107] Leyland, G. (2010) 'Maximising benefits of ITQ management in the Western Rock Lobster fishery' Western Australian Fishing Industry Council and Fisheries Research and Development Corporation

[108] Ogier, E. (2016) 'Lever opportunities under the Aquatic Resources management Act (WA): benefit sharing, re-allocation and co-management in practice' Institute of Marine and Antarctic Studies and Fisheries Research and Development Corporation

[109] (2020) 'Review and update harvest strategy for West Coast Rock Lobster Harvest Strategy and Control Rules 2014-2019' Fisheries Management Paper No. 264, Department of Primary Industries and Regional Development, Western Australian Government

Noting, the commercial nature of much of the research in this space, understanding potential market access risk at a strategic level and being able to pre-emptively respond as an industry is research that can and should be under-taken at a precompetitive level.

Historical research has included:

- **General -** in 2006 a project was initiated to expand an existing Global Lobster Market Database that focused exclusively on western rock lobster to include all lobster industries and all Australian lobster markets. While the objective of this exercise was to improve market intelligence and information for use by all Australian lobster industries for marketing purposes, this information could potentially be used to assess and evaluate market access risk[110]. In more recent times, the Western Rock Lobster Council has commissioned a significant body of work designed to generate a better understanding of markets for western rock lobster[111].

- **PRC market** - another study commissioned by the former Western Australian Government Department of Fisheries analyses trends in prices and volumes of lobster imports to the PRC. The focus of the study is to develop an understanding of how price and volume is related for lobster and how demand drivers in the PRC have influenced price over time. While the primary focus is on western rock lobster, the study suggests that lobster from various jurisdictions compete with each other[112].

Industry dynamics

The western rock lobster industry is currently navigating a period of consolidation within the fishing and processing stages of the supply chain. Understanding the nature of these changes, their driving forces and probable outcomes will help fishers and processors make effective strategic and investment decisions.

Theme 5: Enhancing social license to operate

Community license to operate is core business for all primary industries. For a primary industry that operates in a public space and utilises a shared resource, it is of paramount importance.

The western rock lobster industry can only understand community perceptions toward the industry and develop initiatives to promote license to operate if it understands trends in community attitudes and beliefs. It can then develop solutions to alleviate concerns and promote community support for the industry.

As observed in Figure 39, there have been 21 historical research projects undertaken under Theme 5. Six of these were commenced in 2020.

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[110] Gibson, A. (2006) 'Expand and develop the WA specific global lobster market database', Western Rock Lobster Development Association and Fisheries Research and Development Corporation
[111] Western Rock Lobster Council (2017) 'Understanding the markets for Western Rock Lobster'
[112] Economic Research Associates (2015) 'An analysis of the demand for Western Rock Lobster: a report prepared for the Western Australian Department of Fisheries', Department of Fisheries, Western Australian Government
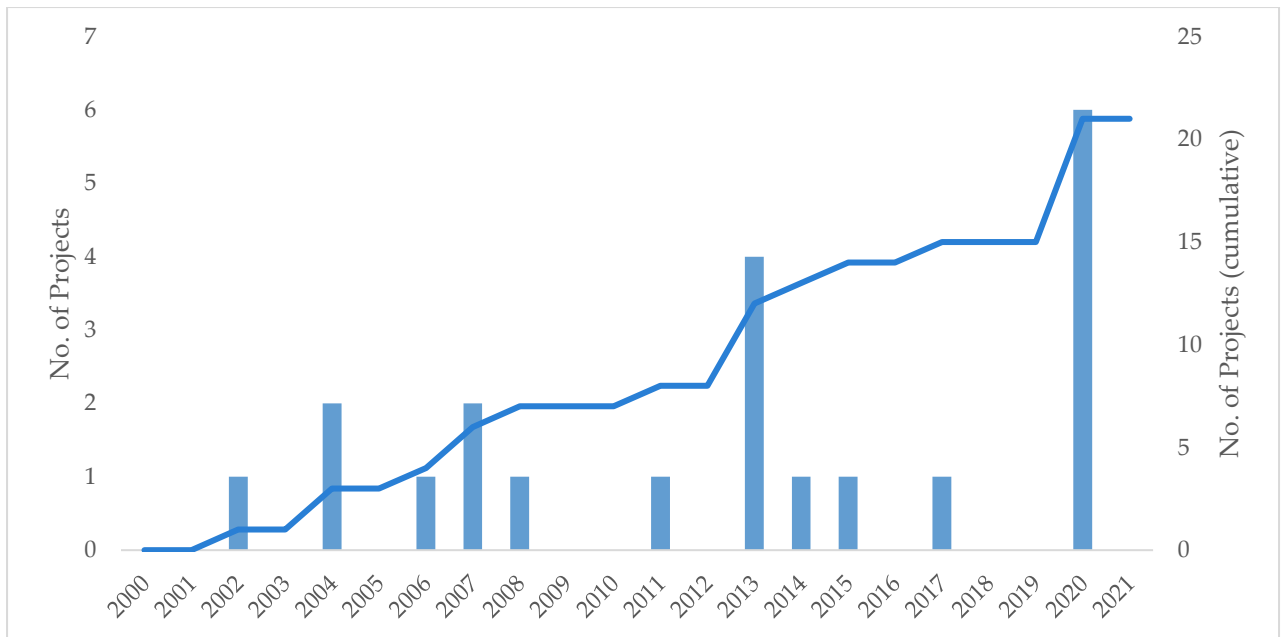
FIGURE 39 – FREQUENCY OF RESEARCH REPORTING UNDER THEME 5

Further to this, Figure 40 demonstrates that more than half of these have been undertaken under Program C – Community Engagement. Three of the community engagement projects commenced in 2020, reflecting the issues recently identified importance to the western rock lobster industry.
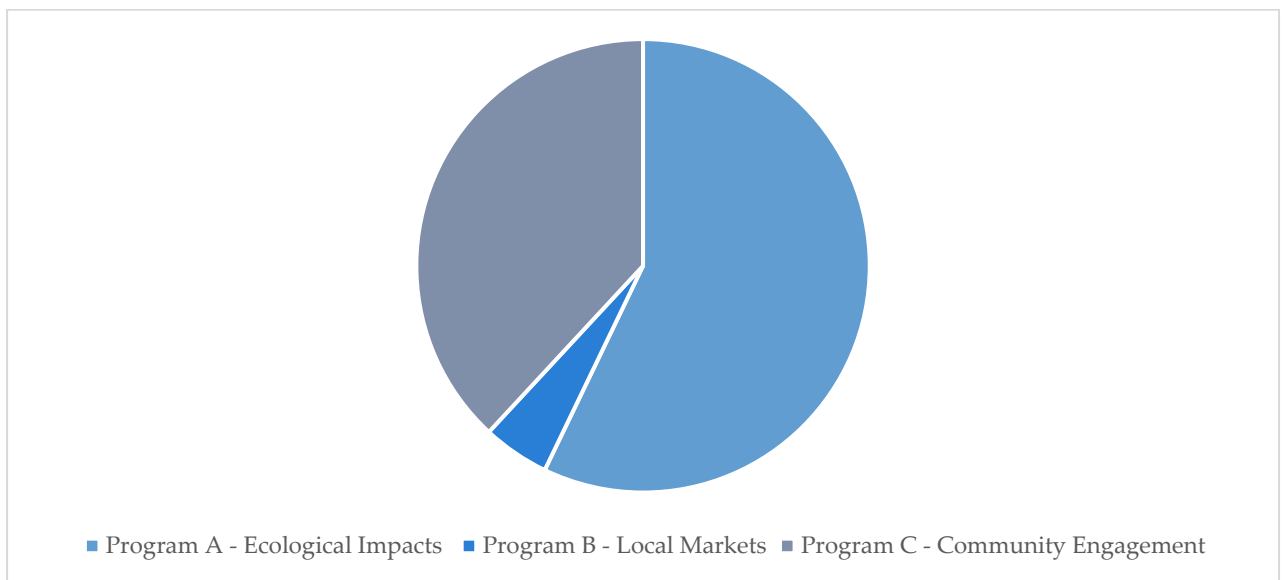
FIGURE 40 – MAIN TOPICS OF FOCUS OF HISTORICAL RESEARCH UNDERTAKEN UNDER THEME 5

Program A: Ecological impacts of the western rock lobster industry

Manging the ecological impact of commercial western rock lobster fishing is important for sustaining the natural resource, MSC accreditation and social license to operate. Given, this breadth of impact, it is not surprising there has been considerable historical research in this area.

- **Survival of returned catch** - the western rock lobster fishing process requires the return of a significant portion of the catch – primarily undersized or 'berried' females – for the purposes of ensuring sustainability of the natural resource.
  - One study endeavoured to determine the effects of commercial capture with or without cold stunning on the survival and growth of returned protected western rock lobster by filming the returned lobsters in the wild. This demonstrated that lobsters spending excessive periods of time in the stun tank at 5 to 10 °C showed delayed recovery following return to the ocean[113].

- **Impact on deep water ecosystems** – the western rock lobster fishing industry generally has a poorer understanding of deep-water ecosystems compared to the shallower fishing zones. Several studies have endeavoured to address this:
  - A study published in 2008, endeavoured to address the gap in understanding about the effects of the western rock lobster fishery on deep water ecosystems as a component of the MSC accreditation process. It specifically explored the relationship between deep water habitat and density and size distribution to form preliminary evaluations on the impact of deep water fishing on biomass[114].
  - In response to the MSC re-certification action plan, a study identified further gaps in knowledge of deep water ecosystems by comparing fished and unfished areas of the deep water ecosystem to understand the impact of western rock lobster fishing in deep water ecosystems[115].

- **Impact of commercial fishing on ecosystems -** a study designed to assess the impact of the commercial fishing effort on the western rock lobster natural resource by simulating the effects of changes in recruitment and commercial fishing on the western rock lobster biomass over a 20-year period, found that the western rock lobster biomass and associated predators and prey were more sensitive to fishing than variations in recruitment. The model also predicts that the variations in western rock lobster biomass, whether induced from fishing mortality or declining puerulus settlement, have a relatively small effect on the biomass of the main predators or prey of lobster[116].

- **Impact on endangered fauna-** several studies aim to attain a greater understanding of interactions between Western Australian fisheries and endangered fauna at an individual fishery and bioregional resolution.
  - While the main issue identified by this study was identification of threat to Australian sealions by other fisheries, it also modelled rates of entanglement of humpback whales in the western rock lobster fishery. It suggested that increases

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[113] Davidson, G. (2002) 'The effect of on-board cold water stunning on the survival and growth of caught and returned Western Rock Lobsters', Fisheries Research and Development Corporation and Geraldton Fishermen's Cooperative

[114] Bellchambers, L. (2004) 'The effects of Western Rock Lobster fishing on the deep water ecosystems off the west coast of Western Australia', Fisheries Research and Development Corporation, Western Australian Government Department of Primary Industries and Regional Development

[115] Bellchambers, L. and Pember, M. (2008) 'Assessing the ecological impact of the Western Rock Lobster fishery in fished and unfished areas', Fisheries Research Report No. 254, Fisheries Research and Development Corporation and Western Australian Government Department of Fisheries

[116] Lozano-Montes, H., Lonegran, N., Babcock, R. and Caputi, N. (2013) 'Evaluating the ecosystem effects of variation in recruitment and fishing effort in the Western Rock Lobster fishery', *Fisheries Research,* 145, 128-135

in the population of humpback whales will not result in any appreciable increase in the rate of entanglements across the fishery[117].

- o Regardless, a later study assessed the cost-benefit of mitigation measures to prevent entanglement of whales in western rock lobster fishing gear[118].

- o An additional study determined that to address increased entanglement caused by new winter fishing from adoption of ITQ, fishing gear modifications are required. The study assessed the effectiveness of potential modifications and collected additional information required to determine the spatial and temporal extent of migrating whales and overlap with commercial fishers[119].

- o A further study determined and implemented the appropriate gear modifications and management to reduce whale entanglement and provided clear scientific testing of the gear modifications, incorporating new practices into the Code of Practice for the western rock lobster fishery to ensure adoption and extension of practices[120].

- o Whale entanglement mitigation efforts are currently being evaluated[121].

- ▪ **Waste management** - to address the landfill disposal practice that is typical of western rock lobster processing waste and to develop a potential alternative revenue source for lobster processors, one study characterised and optimised various chitosan and glucosamine products and compared them to other international products and scoped a scalable environmentally friendly process suitable for extracting chitin from frozen western rock lobster heads and subsequently convert to chitosan and glucosamine, products that have potential application in nano and biotechnologies[122]. In more recent times, impact research has focused on plastics[123]

- ▪ **Carbon footprint** - Fuel is a significant component of the cost of fishing for western rock lobster and major contributor to its carbon footprint. One study assessed the applicability of bio-fuels to the western rock lobster industry for the purposes of informing a business case advocating for the adoption of biofuels by the industry and to ensure fishers are able to make an informed choice as a to whether biofuels are a suitable alternative fuel source for their vessels[124].

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[117] Campbell, R. (2007) 'Assessing and managing interactions of protected and listed marine species with commercial fisheries in Western Australia' Fisheries Research Report No. 223, Fisheries Research and Development Corporation and Western Australian Government Department of Fisheries

[118] Future Oceans Pty Ltd (2013) 'Cost-benefit analysis of mitigation measures to reduce interactions between commercial fishing hear and whales', Fisheries Research and Development Corporation.

[119] DPIRD 'Cost-benefit analysis of mitigation measures to reduce interactions between commercial fishing hear and whales', Fisheries Research and Development Corporation.

[120] How, J., Coughran, D., Double, M., Rushworth, K., Hebiton, B., Smith, J., Harrison, N., Taylor, M., Paton, D., McPherson, C., Recalde Salas, A., Salgado-Kent, C. and de Lestang, S. (2014) 'Mitigation measures to reduce entanglements of migrating whales with commercial fishing gear', Fisheries Research Report No. 304, Fisheries Research and Development Corporation and Western Australian Government Department of Primary Industries and Regional Development

[121] (2020) 'Evaluate whale mitigation arrangements'

[122] Raston, C. and Makha, M. (2006) 'Examination of green sustainable process technology for preparing chitin and associated derivatives from rock lobster waste', Fisheries Research and Development Corporation and The University of Western Australia

[123] (2020) 'Minimise plastic waste from rock lobster pots'

[124] Ryan, W. and Poole, M. (2007) 'Feasibility study for the use of biofuel for the Western Rock Lobster industry', Fisheries Research and Development Corporation and Kondinin Group

Program B: Local market access

Historically, the significant premiums that western rock lobster attracts in certain overseas, particularly Asian, seafood markets have meant that supply to the domestic market from the commercial sector has been limited. This has had two perceived impacts. Firstly, the product is relatively expensive and in periods of high demand (such as the Festive Season) prices can be very high and the product difficult to obtain. Secondly, scarcity and price means that local restaurants struggle to offer the local iconic cuisine with frequency and affordability. Anecdotally, this has caused some angst among parts of the Western Australian community and has been a politicised issue.

While the reality of this issue needs to be assessed in the context of a significant recreational sector and the product's luxury status, industry has responded with an intent to improve affordable local market access through the Back-of-Boats (BOB) sales program. While seemingly popular the BOB program has some operational challenges and there is concern as to the distortionary effects that programs that mandate a 'domestic market' quota may have on key lobster markets. Consequently, recent study has reviewed the domestic lobster supply program and presented options for including domestic supply as a component of the harvest strategy[125].

Program C: Effective community engagement

Managing social license to operate requires an understanding of key stakeholder attitudes and beliefs, how they relate to the western rock lobster industry and its activities and how those attitudes and beliefs are evolving. It also involves understanding how industry can meet community expectations whilst optimising sustainability and profitability.

- **Relationship between western rock lobster industry and its communities** - an early study established a database of quantitative and qualitative social indicators for communities that host the western rock lobster fleet. These are designed to facilitate an integrated socio-economic assessment of a range of industry management options, contributing to the development of a framework and predictive sustainability assessment model that integrates social, environmental and economic data for use in predicting the wider effects of changes to the management of the fishery on host communities[126].

- **Demonstrating industry's economic contribution** - another study modelled and assessed the economic contribution of the western rock lobster industry to the Australian, Western Australian and Western Australian regional economies, including GVP, value-add, direct and indirect employment[127].

- **Supporting the recreational sector** - a current study is examining potential to simplify management and compliance arrangements pertaining to the recreational sector principally related to new whale mitigation gear and storage of lobsters[128]. While a

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[125] DPIRD (2020) 'Review of domestic lobster supply program options for potential inclusion in the Harvest Strategy'

[126] Huddleston, V. and Tonts, M. (2004) 'A scenario analysis of the social impact of the Western Rock Lobster industry management option on fleet hosting communities', Fisheries Research and Development Corporation, Institute for Regional Development at The University of Western Australia

[127] ACIL Allen (2017) ' Economic contribution of the Western Rock Lobster industry to Western Australia and Australia', Fisheries Research and Development Corporation and Western Rock Lobster Council

[128] DPIRD (2020) 'Review recreational lobster management arrangements'

collaborative project between the Western Rock Lobster Council and Recfishwest is seeking to improve catch estimates from the recreational sector[129]

- **Using third-party accreditation as a tool for maintaining social license** - part of the rationale behind pursuing MSC certification was that poor public perception of Western Australia's fishing industry could potentially be mitigated by MSC certification. The extension of MSC certification included how best to communicate the certification so as to build public confidence in the fishing industry[130]. A new version of MSC is currently being scoped[131]. Another project has developed a non-ecological risk framework that is compliant to Australian and New Zealand ISO standards 3100/2009 Risk Management Principles and Guidelines for the Western Rock Lobster Council. While this serves a comprehensive set of industry risk management prerogatives, it also provides the community with confidence the peak body is proactively managing issues that impact on its license to operate[132].

- **Managing the balance -** another study determined optimal feasible strategies for sustaining industry profitability, optimal governance structures for securing regulatory objectives at the lowest cost and identified the management information necessary to delivers sustainable commercial outcomes for the industry over time[133].

Theme 6: Supporting industry adoption of research outcomes and communication to stakeholders

The outcomes of research are only valuable if they can be translated into solutions that can be practically and economically implemented by fishing businesses, processors and other western rock lobster supply chain stakeholders.

Effective adoption of research by industry and communication of outcomes to stakeholders requires several key interactions between researchers, industry and other stakeholders:

- **Industry engagement** – this involves the engagement of industry and stakeholders into the design and conduct of research projects. This ensures practical relevance to industry, better access to industry data and tacit knowledge, greater likelihood of engagement in pilot programs, all of which ultimately increases the likelihood of an adoptable practical outcome from the research that meets the end-user's needs.

- **Effective communication of outcomes of research** – this involves the effective translation of research outcomes into mediums and forums focused on its practical application. This is especially relevant for the results of pilot trials and research focused on technologies, processes and policies that are intended for adoption by industry. Effective communication requires the bridging of a language gap between academics and industry and ensuring the medium and forum is effective for the target audience.

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[129] DPIRD (2020) 'Providing support to joint Recfishwest and Western Rock Lobster Council to improve recreational lobster catch surveys'
[130] Leyland, G. (2013) 'Extension of MSC Certification for Western Australian fisheries' Fisheries Research and Development Corporation and Western Australian Fishing Industry Council
[131] DPIRD (2020) 'Scoping of new MSC version'
[132] Western Rock Lobster Council (2015) 'Review and analysis of the risks associated with the sustainable development of the Western Australian rock lobster industry', Fisheries Research and Development Corporation
[133] McLeod, P., Lindner, R. and Nicholls, J. (2011) 'Governance, social and economic sustainability of WA's Western Rock Lobster and finfish industries', Fisheries Research and Development Corporation

- **Translation of outcomes into adoptable products, practices and technologies** – this includes the commercialisation of research outcomes, development of technology and formulation of policies, processes and practices for easy adoption by fishing businesses, supply chain participants and other stakeholders. The likelihood of this being successful is substantially increased if the target adopter has been included in the research project from its outset.

As seen in Figure 41 have been ten historical research projects undertaken within Theme 6. Most of these have commenced within the past decade.
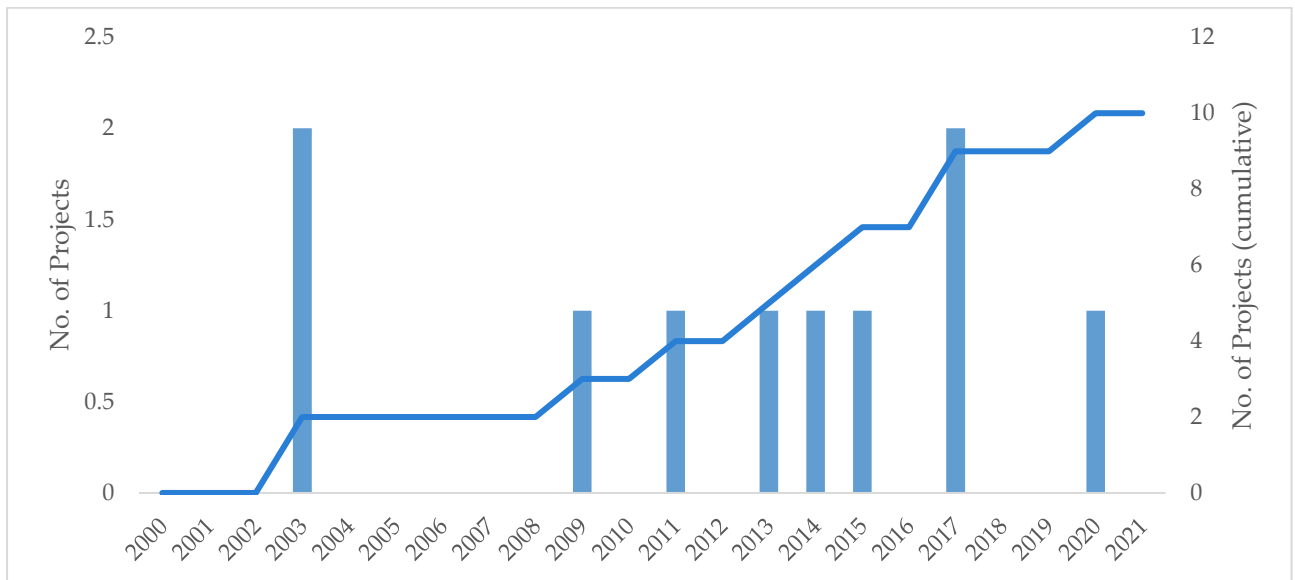
FIGURE 41 – FREQUENCY OF RESEARCH REPORTING UNDER THEME 6

Figure 42 shows that all of Theme 6's historical and current projects have largely involved industry engagement and communication of research outcomes to industry and other stakeholders.
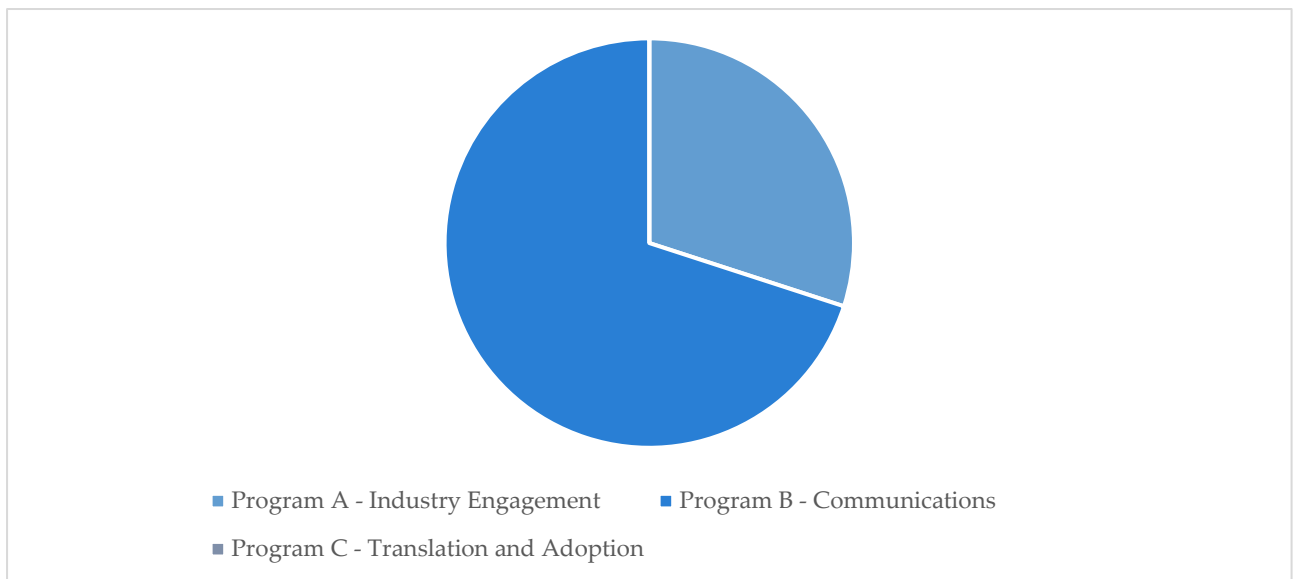

FIGURE 42 - MAIN TOPICS OF FOCUS OF HISTORICAL RESEARCH UNDERTAKEN UNDER THEME 6

Program A: Industry engagement

As articulated above, Industry Engagement is important for numerous reasons. While project applications typically require evidence of industry support, there is currently little structure that guarantees adequate industry engagement through implementation and delivery of outcomes, with this occurring mainly on an *ad hoc* basis. Improving this is a key objective of the proposed Western Rock Lobster Research Network.

To date, some industry engagement has occurred through the development of a few research, development and extension plans (RD&E plans):

- Three studies have been RD&E plans for the western rock lobster industry and Council. These are designed to better coordinate research undertaken in the western rock lobster industry to cost effectively achieve the desired research outcomes.

Program B: Communications

Currently, the primary mechanism for communicating research outcomes is through the FRDC's website (where a project is funded by the FRDC), Western Rock Lobster Council website, and Western Rock Lobster Council member communications (e.g. member correspondence, coastal tours and other member forums).

A historical research project sought to enhance the communications program and revolved around an alteration to communication plan related to one of the research, development and extension projects discussed below.

Another historical research project was designed to build community and industry knowledge on the effects of climate change on Australian fishing industries. This project was designed to synthesis and simplify messaging of adaptation strategies in a regionally specific way.

Additionally, the focus of Theme 6 is largely on attendance at events and conferences. These were designed to build industry capacity to engage in research and policy, as well as educate industry about recent research outcomes. Events that industry members received funding to attend include:

- 'Engaging Leaders Innovating Across Sectors' (ELIAS)
- Trans Tasman Rock Lobster Congress 2015
- Western Rocklobster Fishery Industry Congress
- 3rd National Rock Lobster Congress – 2003

Funding has also been allocated towards organising and hosting the International Lobster Conference in Western Australia.

Program C: Translation and adoption

As the main focus on Theme 6, Program C refers to the process for ensuring that fishing businesses, supply chain participants and other stakeholders can easily adopt research into their systems and operations.

While for some research outcomes this will involve a relatively simple communications process. In other more complex areas a specific knowledge or technology translation and adoption strategy will need to be implemented.