Enhancing the Understanding of the Value Provided to Fisheries by Man-made Aquatic Structures.

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24 August 2021

FRDC Project No **2018-053**

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ISBN **978-0-646-84171-7**

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FRDC-2018-053

2021

This publication (and any information sourced from it) should be attributed to Harvey, E.S., Ackermann, F., Burton, M., Clifton, J., Elrick-Barr, C.E., Zimmerhackel, J.S., Hill, G., Newman, S.J., Shaw, J.L., Pagano, M., McLeod, P., McLean, D.L., and Partridge. J.C. Fisheries Research and Development Corporation. 2021. *Enhancing the Understanding of the Value Provided to Fisheries by Man-Made Aquatic Structures.* August, 2021.

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Foreword

In Western Australia, it is estimated that there are more than 7,400 man-made marine structures. These include structures associated with the oil and gas industry, shipwrecks, artificial reefs, break walls, structures associated with harbours, jetties, marine navigation markers. Around Australia, artificial reefs are being installed to enhance recreational fishing and diving experiences while other installations (e.g. Oyster Reefs) help to improve water quality and restore marine biodiversity. The fate of the many items of oil and gas infrastructure (platforms, wells, pipelines, mattresses, weights, mooring lines etc.) also need to be considered as they come to the end of their life. Around the globe, research suggests that there are substantial ecological communities growing on these structures and you only need to look at YouTube to appreciate they are used and valued by recreational and charter fishers in the Gulf of Mexico.

In the coming years, Western Australia and other states will plan, seek regulatory approval, and build new infrastructure in the marine environment. This may be in the form of new ports, offshore renewable energy, subsea cables and aquaculture facilities. The planning and approvals processes for these projects need to take into consideration the hopes, aspirations, and concerns of all the stakeholders.

In 2018, the state's recreational and commercial fishers (Recfishwest and WAFIC), commissioned a program of research as part of a Fisheries Research Development Corporation project aimed at documenting the social and economic values and benefits of a range of stakeholders towards man-made marine structures.

Using a series of case studies, the research group demonstrated several different sampling and analytical strategies to familiarise end users with what is possible and provided an overview of identified economic and social values as well as issues and opportunities associated with people's values and perceptions. The webinar from this presentation is available at wamsi.org.au/project/webinar-frdc-man-made-structures. A guide was also produced that can be used to determine options for collecting social and economic data.

This report is the result of a collaboration of researchers and subject experts from Curtin University, the University of Western Australia, Australian Institute of Marine Science, and the Western Australian Department of Primary Industries and Regional Development (Fisheries). The science focus was guided by a steering committee with industry representation from Chevron, BHP, Woodside, Santos, National Energy Resources Australia, WA Fisheries Research Advisory Board, Department of Primary Industries and Regional Development and the National Offshore Petroleum Safety and Environmental Management Authority. The outcome from this cross-sectoral collaboration, facilitated by the Western Australian Marine Science Institution, has provided an important science-based benchmark documenting the social, economic and environmental considerations associated with man-made marine structures. It is a vital point of reference for regulators, proponents and other stakeholders when considering the social and economic impact of installing or removing man-made marine structures.

Dr Luke Twomey
CEO
Western Australian Marine Science Institution

24 August 2021.

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Acknowledgments

We would like to acknowledge and thank the members of the project Steering committee (Andrew Rowland, Recfishwest; Alex Ogg and Mannie Shea, Western Australian Fishing Industry Council; Andrew Taylor, National Energy Resource Australia; Chris Jones and Michael Marnane, Chevron; Luke Smith and Kate Swain, Woodside; Libby Howitt, Santos; Tim Cooper, BHP and Brett McCallum, chair of the WA RAC. We thank and acknowledge Luke Twomey from the Western Australian Marine Science Institute (WAMSI) who chaired the steering committee. Also, Trish Wells and Aleta Johnston at WAMSI for logistical assistance with meetings and the organising and supporting the final webinar.

We are grateful to the numerous stakeholders who were willing to participate in the focus groups. Also, to Todd Bond, Laura Fullwood, Ariel Neri, Ben Radford and Mark Case who assisted collating data on man-made marine structures in Western Australia. James Florisson and Steph Watts assisted in providing metadata on artificial reefs in Western Australia.

We thank Chevron, and in particular Michael Marnane and Travis Elsdon for their academic and strategic advice and acknowledge that without Chevron's cash contribution this project would not have occurred.

Abbreviations

AR	Artificial reef
AUD	Australian dollars
CS	Consumer surplus
CVM	Contingent Valuation Method
DCE	Discrete Choice Experiment
EEL	Extended economic legitimacy
EIAR	Exmouth Integrated Artificial Reef
MMS	Man-made marine structures
NGO	Non-governmental organisation
O&G	Oil and gas
RAC	Research Advisory Committee
RUM	Random Utility Model
SLO	Social license to operate
TC	Travel cost
WA	Western Australia
WTP	Willingness to pay

Section 1: Executive summary

Overview

This report outlines the social and economic values and benefits associated with man-made marine structures (MMS) in Western Australia.

The report is the outcome of research undertaken by staff from Curtin University (Professors Euan Harvey and Fran Ackermann, and Ms Georgina Hill), The University of Western Australia (Associate Professors Michael Burton and Julian Partridge, Drs Julian Clifton, Carmen Elrick-Barr, Johanna Zimmerhackel) in collaboration with, and with guidance from staff at the Department of Primary Industries and Regional Development (Dr Stephen Newman, Mr Mark Pagano), the Western Australian Marine Science Institution (Dr Jenny Shaw) and the Australian Institute of Marine Science (Dr Dianne McLean).

During 2019 and 2020 the researchers undertook seven online surveys which focussed on understanding the social and economic benefits and values that recreational and commercial fishers, divers and other users gained from using MMS in Western Australia. This was complemented by eleven focus groups which included representatives from the commercial and recreational fishers, but also the Oil and Gas (O&G) sector, regulators (state and federal), conservation, non-government organisations (NGOs), scientific sectors, and the general community. The researchers used data to develop five case studies representing a range of different structures and end users. These case studies focussed on inshore Thevenard Island subsea O&G infrastructure (incorporating recreational fishing), Woodside's Echo Yodel offshore subsea O&G infrastructure (incorporating commercial fishing), the Exmouth Integrated Artificial Reef (recreational fishing), the Exmouth Navy Pier (diving tourism), and the iconic Busselton Jetty in Southwestern Australia, which is used for tourism, by recreational fishers, divers, swimmers and many other stakeholders. A guidebook was produced outlining the different methods of identifying social and economic values, along with the types of data required, and the approaches to collecting this data. The guidebook also outlines the advantages, disadvantages and resource needs for each method. A database of the MMS in Western Australia was also compiled and made accessible online.

Background

In 2018, the state's recreational and commercial fishers (represented by the peak bodies Recfishwest and WAFIC) commissioned a program of research as part of a Fisheries Research Development Corporation project aimed at documenting the social and economic values and benefits that stakeholders obtain from MMS in Western Australia. These structures include shipwrecks, artificial reefs, break walls, structures associated with harbours, jetties, marine navigation markers, and O&G infrastructure such as platforms, wells, and pipelines. These structures are used by a wide range of groups in the community for recreation. Some commercial fishers are designing, constructing and installing structures for aquaculture (e.g. abalone and coral for the aquarium trade, floating cages for fish). MMS can also generate direct and indirect income for local communities and businesses with people paying directly to use a resource, but also paying for goods and services locally to support their use. Members of the community, both those who use and those who do not directly use these structures can benefit from the existence of these structures.

Large investments have been made in the construction and installation of purpose-built structures on the seafloor to enhance the experience of recreational fishers (e.g. the Exmouth Integrated Artificial Reef) and divers (e.g. HMAS SWAN) with more structures planned. There will also be significant costs associated with proposed and future ports and offshore wind and wave farms. As a consequence, it is important to understand how to optimise the benefits of these structures for as many stakeholders as is

practicable. While new structures are being proposed or installed on the North West Shelf of Australia and elsewhere, O&G infrastructure is generally reaching the end of its productive life and requires decisions on decommissioning strategies. The current legislative requirement and regulatory framework for decommissioning O&G infrastructure in Commonwealth waters (see Sect 572(3) of the Offshore Petroleum and Greenhouse Gas Storage Act 2006) requires the complete removal of structures. The legalisation provides for engagement with persons whose interests, activities and functions may be affected. As a consequence, regulators may support alternative strategies, such as leaving infrastructure in place, or relocation to create artificial reefs, if the risks and impacts are minimised and there are clear environmental, social, and economic benefits.

There is an increasing number of peer-reviewed manuscripts detailing the ecological values and potential benefits of these structures in Western Australia (e.g. McLean et. al. 2018, 2019; Bond et al. 2018a, b, Schramm et al. 2020). However, there is a lack of social and economic data which can inform discussions and decision making, both within Western Australia, nationally across Australia and globally. To inform discussions and decisions there is a need for information on the ecological, economic and social value of MMS to recreational and commercial fishers and other stakeholders, and not just the impacts of MMS on the ecology. For decommissioning in particular, there is a need to understand the opportunities and risks of decommissioning strategies to fishers and other stakeholder groups (e.g. tourism and the wider community) and to document the attitudes of stakeholders, including the broader community. It is also important to recognise that the values of stakeholders may change over time in response to new information about the risks and impacts of MMS. There is a need to ensure our understanding is current.

Aims/objectives

To contribute information to this discussion this research aimed to:

1) Augment and integrate analytical methods to identify and explore the socioeconomic values of MMS in Western Australia.
2) Collate a list and description of the MMS in the marine environment in Western Australian and the associated social, economic and biodiversity data.
3) Collect and collate data on the social and economic values of MMS in Western Australia, including five case studies.
4) Develop a guide for undertaking socioeconomic evaluations of MMS which can be used throughout Australia (and other locations), and direct end users on approaches and strategies depending on their information requirements.

One of the goals of this project was to demonstrate the value of social and economic data, not only to decision makers, but to proponents of projects as a way of understanding the concerns of different stakeholders during the conceptualisation of a project. Proponents can use this information to create opportunities that derive benefits for different stakeholders.

Methodology

The project was underpinned by a literature review, which set the context for the primary data collection. Primary data collection used seven online surveys to obtain information from different target audiences. The social component of the online surveys collected data on respondents' preferences and attitudes towards manmade marine structures, as well as socio-demographic information. Recruitment was targeted to the audience of interest, which in the case of the social science surveys was primarily users of MMS (e.g. recreational fishers and divers). The online components of economic surveys identified details of previous behaviour (visitation rates etc.) or derived stated preferences about how a user might behave under hypothetical outcomes for the future of MMS. We also used focus groups (both face to face and online) to create a more in-depth engagement with a smaller number of stakeholders.

The social and economic surveys took 15-20 minutes to complete, while the focus group approaches could take up to 3 hours, with these providing a more nuanced perspective of the issues, concerns, benefits, values and opportunities associated with MMS as perceived by different stakeholders, and thus develop a shared understanding.

Results/key findings

The literature review revealed that limited primary social and economic data has been collected on MMS in Australia. While the values and benefits of MMS from other countries can be generalised and transferred to Australia, the usefulness of the information depends on the location specificity (i.e. local fine scale location specific areas of interest) required by proponents or decision makers. The case studies we present generated location specific social and economic values.

As a generalisation, most stakeholders believed that there were social, environmental, and economic values associated with MMS. Stakeholders raised concerns about MMS causing habitat degradation and marine pollution due to chemicals leaching or leaking from structures. Some of these concerns can be resolved by independent, robust, evidence-based case studies with the environmental costs and benefits of different future scenarios clearly communicated.

We also demonstrated that there are significant direct and indirect economic benefits associated with MMS. In coming years there will be an increasing number of proposals to create and deploy new MMS through the creation of ports and jetties, the installation of offshore renewable energy platforms, artificial reefs and other types of infrastructure. We believe there is a need to maximise the environmental, social and economic benefits that can be gained from the installation of these structures. This can be undertaken through eco-engineering which aims to maximise the ecological value of future structures by incorporating knowledge of ecological processes into engineering design principles. By considering the socio-economic values of a range of potential users during planning processes, it may be possible to not only achieve the primary goal of an infrastructure development program, but also maximise the social and economic benefits to potential users and avoid adverse stakeholder responses. Where structures have a temporary lifetime, and particularly where the legislative base-case requires removal, engineers need to ensure that structures are designed and maintained so they can be easily removed from the seafloor. When they cannot, they need to ensure that the structures that are left in place are designed to be environmentally appropriate and meet the social and environmental values and expectations of the community.

Implications for relevant stakeholders

The information generated by this project provides a strong foundation to facilitate understanding of the values of MMS across diverse user groups into the future. To be trusted by all stakeholders, policy around the installation of new structures, and the removal of existing structures, must be informed by case studies that present robust and independent environmental, social, and economic data. The process also needs to engage and educate stakeholders and the broader community about the issues and opportunities.

The data we generated suggests there is the belief and credence among stakeholders, that there is a need for greater regulatory certainty. This is of particular importance to end users. Any changes to the regulatory framework need to address potential conflict between different users of MMS by providing mechanisms to allocate the use of specific structures to a particular sector, and/or to incorporate property rights.

Public acceptance, and indeed enthusiasm for MMS can be further developed through ongoing and continued extension strategies (communication plans) that highlight their environmental and socioeconomic benefits. These benefits are well established via international and domestic peer reviewed studies and the case studies we present herein. This information provides a means to bridge the otherwise disparate views of some stakeholder groups. These benefits can be realised over short timescales and can be described in accessible, non-technical terms. Building a consensus and positive view on MMS through reference to these attributes will help mitigate any adverse perceptions and values.

In the context of decommissioning O&G infrastructure, public confidence could be strengthened through recognition that the approvals process for decommissioning in Commonwealth waters requires evaluation of all environmental impacts and risks (not just benefits) and a demonstration that these impacts and risks will be of acceptable levels and reduced to as low as reasonably practicable.

It is important to note that the key approval required to install an artificial reef in Australia is the Commonwealth *Environmental Protection (Sea Dumping) Act 1981*, administered by the Department of Agriculture, Water and the Environment (DAWE; Australian Government). This in essence means that protection of the environment is paramount for the installation of any man-made structure.

Recommendations

1) The magnitude and breadth of the socio-economic values and benefits that arise from appropriately designed man-made marine structures (as identified by this report) need to be broadly socialized and communicated (reflecting the breadth of engagement). Understanding these benefits is a key component to guide any future decisions about MMS.
2) There is a need to develop greater regulatory clarity around the installation and removal of man-made marine structures (e.g., expanding and building on the Offshore Petroleum and Greenhouse Gas Storage Act 2006; developing guides for the assessment of permit applications for artificial reefs under the *Environmental Protection (Sea Dumping) Act 1981*). There needs to be clear guidelines developed across all levels of Government that reflects the needs of all stakeholder groups. While challenging, the objective would be to develop clear and transparent guidelines (or policy frameworks and regulations) that are consistent across the country. Specific suggested changes to guidelines or regulatory reforms should consider the following:
    a) policy development that seeks to guide future proposals for the installation of purpose built and integrated (using repurposed subsea infrastructure) reefs in Australia.
    b) incorporating social and economic data that reflect the values, issues and opportunities raised by stakeholders to maximise benefits is an important consideration for any guidelines. Highlighting benefits is essential for the development of social license for a wide range of projects from decommissioning of O&G infrastructure to the design and installation of artificial reefs, and the development of harbours and ports that are environmentally appropriate.
3) In Western Australia, the development and implementation of purpose-built artificial reefs in WA commenced in 2012. Since 2012, seven artificial reefs have been installed without any inter sector conflict. All reefs belong to the wider community. The key has been appropriate constraint mapping and consultation among multiple stakeholder groups prior to reefs being fabricated and deployed. This is a fundamental principle for any ongoing program.
4) There is a need to review the legal liability of MMS in general across governments, with the goal being to maximise the social and economic value that may arise from the development of MMS. In addition, consideration needs to be given to the development of explicit frameworks that identify end of life liability, as well as the costs and actions needed for site remediation and/or creation of MMS.

5) Importantly, there needs to be a more strategic approach to habitat enhancement structures in all jurisdictions. At present many purpose-built artificial reefs are simply located based on political desires and/or because there is a proposed decommissioning opportunity at the site. A more strategic approach is required from industry to validate and justify where purpose-built reefs are placed with a long-term vision to enhance both fish production and amenity value.
6) That further research on key gaps in ecological knowledge is needed to understand the net benefit of MMS for enhancing the condition of the marine environment: e.g., whether MMS provide habitats that increase fish productivity (or just act to attract and aggregate fish stocks); whether MMS are important for the protection of vulnerable species; how MMS will degrade over time and what environmental impacts may result, whether MMS could increase the risk invasive marine species.

Keywords

Man-made marine structures, socioeconomics, benefits, values, opportunities, recreational fishing, commercial fishing, diving, tourism, artificial reefs, jetties, piers, shipwrecks, platforms, pipelines, decommissioning, planning, resource management, policy development.

Section 2: Introduction

Background

This project was identified by the WA RAC as a FRDC priority in its November 2017 funding round with this project being funded in July of 2019.

There are in excess 7400 items of MMS in Western Australian coastal and offshore waters (see Appendix 1). The MMS listed in Appendix 1 include shipwrecks, artificial reefs, break walls, structures associated with harbours, jetties, marine navigation markers and O&G infrastructure such as platforms, wells, and pipelines (Perkol-Finkel and Sella, 2015), but do not include aquaculture structures or subsea telecommunication infrastructure.

Different types of MMS are used by stakeholders for different purposes. For example, land based recreational fishers are known to use jetties, groynes, and breakwaters (Smallwood, 2011), while those who have access to boats also fish artificial reefs installed to enhance recreational fishing (Keller et al., 2016; Becker et al., 2020; Florisson et al., 2020). International literature shows that recreational and commercial fishers target offshore O&G infrastructure, including platforms and pipelines (Ditton and Auyong, 1984; Stanley and Wilson, 1989; Rouse et al., 2018) with data from Western Australia demonstrating that some commercial fishing effort (e.g. cage trapping) is periodically focussed along O&G pipelines on the North West Shelf (Bond, 2020). Jetties, shipwrecks, and O&G infrastructure are also utilised by recreational divers with some commercial diving tour operators taking customers to these artificial reefs (Stolk et al., 2005, 2007). In Australia, several ships have been deliberately cleaned, made safe and scuttled specifically to create new diving locations and experiences (Dowling et al., 2001). Internationally, O&G platforms are considered to be essential fish habitats in some countries (Love et al., 2006; Helvey, 2002; Claisse et al., 2019), or to have conservation values in areas where marine life is depleted (Friedlander et al., 2014).

Anecdotal data suggests that stakeholders from different sectors have a range of values driven by the types of MMS they use and their experiences using MMS (if at all) (Shaw et al., 2018). Consequently, different stakeholders have different views and perspectives about the issues and opportunities associated with MMS. This project aims to document those issues and opportunities and list, describe, and where possible quantify the social and economic values of stakeholders.

Need/definition of problem

The northwest of Western Australia has important commercial and recreational fisheries and extensive offshore O&G infrastructure. These MMS support a range of demersal and pelagic fish species which are targeted by recreational and commercial fishers (Bond et al., 2018a; Schramm et al., 2020). As this O&G infrastructure reaches the end of its productive life, decisions on decommissioning strategies must be made. The current policy for decommissioning requires complete removal. Regulators may support alternative strategies, such as leaving infrastructure in place, or relocating to create artificial reefs if the risks and impacts are minimised, and there are clear environmental, social, and economic benefits. There is an increasing amount of peer-reviewed literature about the ecological values and potential benefits of these structures in Western Australia (Macreadie et al., 2011; Pradella et al., 2014; Fowler et al., 2015; Bond et al., 2018a, 2018b; McLean et al., 2018, 2019; Schramm et al., 2020). However, there is a lack of social and economic data which can inform discussions and decision making (Shaw et al., 2018).

While the discussion about the fate of O&G infrastructure is occurring, there have been large investments in constructing and installing purpose-built MMS on the seafloor to enhance the experience of recreational fishers and divers. There are also ongoing discussions about the ecological, social, and economic values associated with the restoration of terrestrial (Bond and Lake, 2003; Miller and Hobbs, 2007) and marine habitats (Ellison, 2000; Layton et al., 2020). As a fisheries management tool, the concept of habitat enhancement using artificial reefs designed to increase the recruitment, survival and carrying capacity of species targeted by commercial and recreational fishers is increasing in popularity (Stone, 1982; Bortone et al., 2011).

To inform discussions and decisions there is a need for information on:

1) the ecological, economic and social value of MMS to recreational and commercial fishers and other stakeholders;
2) the attitudes of stakeholders to MMS; and
3) the opportunities and risks of decommissioning strategies to fishers and other stakeholder groups (e.g. tourism).

Why is this important

Social, economic, and ecological data are needed to inform any changes to existing or new policy and legislation regarding the removal of MMS from and/or installation into the sea. We believe that there is a lack of clarity and understanding across the regulatory and management sectors about the application of socioeconomic data to inform decision making on this issue. Similarly, there is a lack of awareness of the methods and techniques that are available for collecting, analysing, and presenting socioeconomic data. There is also a lack of awareness about the types of information that can be generated, the skills required to collect and generate that data, and the time and cost involved. Time and cost will vary depending on the level of detail required. This project has generated social and economic data that is generic to Western Australia, but also case studies that demonstrate the types of data that can be generated at a local scale.

Objectives

The original objectives of this project were:

1) To develop conceptual qualitative, semi-quantitative and quantitative models for describing the socioeconomic values and decide what information is needed to give stakeholders an understanding of the value of man-made aquatic structures in the marine environment.
2) To collate a list and description of the man-made aquatic structures in the marine environment in Western Australian and the associated social, economic and biodiversity data.
3) To collect and collate data on four man-made aquatic structures in the marine environment and develop and compare the costs and benefits of qualitative, semi-quantitative and quantitative models.
4) To develop a decision support system or framework for undertaking socio- economic evaluations of man-made aquatic structures which can be used throughout Australia and guide end users on how to develop qualitative, semi- quantitative and quantitative models depending on their information requirements.

These objectives were refined as the project matured. They were also modified to accommodate the limitations forced on us by running a research project based on interviewing and surveying people during the COVID-19 pandemic. Consequently, the objectives of this project were refined:

1) To augment and integrate analytical methods to identify and explore the socioeconomic values of MMS in Western Australia.
2) To collate a list and description of the MMS in the marine environment in Western Australian and the associated social, economic and biodiversity data.
3) To collect and collate data on the social and economic values of MMS in Western Australia, including five case studies.
4) To develop a guide for undertaking socioeconomic evaluations of MMS which can be used throughout Australia (and other locations), and direct end users on approaches and strategies depending on their information requirements.

Definition of terms

The terms economic, social and socioeconomic values and benefits have different meanings to different stakeholders. In the context of this research on the values of MMS, we define socioeconomic values as being:

"Values that people hold arising from the direct use (e.g. recreational fishing and diving), indirect use (e.g. flow-on effects to the local communities) and non-use (e.g. the existence of marine life; ecosystem values) with reference to MMS. Values may be material (e.g. employment, tourism, fishing catch), relational (e.g. social interaction/connection), or subjective (e.g. memories, perceived aesthetics, community or individual identity). Socioeconomic values can be either positive or negative and will interact with one another over space and time. Values will therefore evolve in response to the social, economic, political and environmental context."

How did we collect data?

For the purposes of data collection and reporting we have divided the project into three components (See Figure 1). These comprise a social component which used online surveys to elicit information from individuals about their values and the positive or negative impacts of MMS. This component is referred to herein as the "social value - individual" component. Secondly, an economic component also used online surveys to collect broad-scale and site-specific information about individuals' economic values. This component is referred to hereon as the "economic value" component. Finally, a third component used a "focus group" approach to gain a comprehensive understanding of how the perceived values differed between stakeholders and sector groups and the issues and opportunities that substantiated them. The focus groups identified the interactions of issues and opportunities on one another and the values. Also, the interactions between different stakeholders (e.g. commercial and recreational fishers). This component is referred to herein as the "social value - group" component. More details about the specific approaches are outlined in the methods below. The research was underpinned by a global literature review (See Appendix 2).

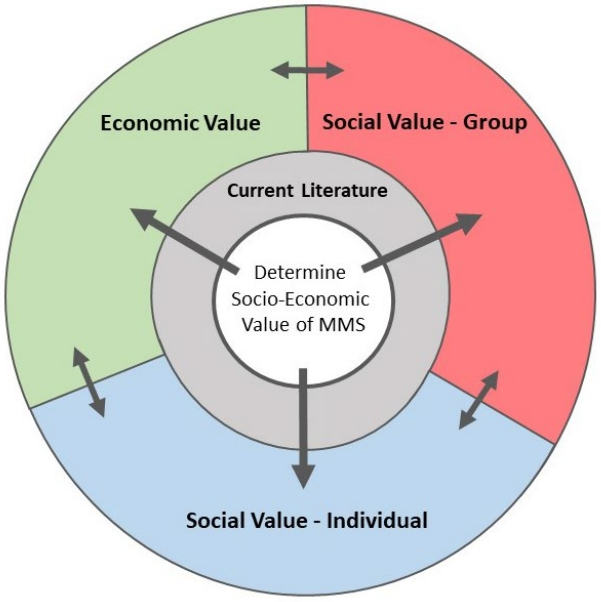
The first phase of this project involved a comprehensive literature review to identify existing relevant data at a global, Australian, Western Australian, and regional scale to identify data gaps and assess their consequences. We also proposed to undertake four case studies on different types of MMS to demonstrate what outputs could be developed using different approaches. These structures included the inshore Thevenard Island subsea O&G infrastructure (incorporating recreational fishing), Woodside's Echo Yodel offshore subsea O&G infrastructure (incorporating commercial fishing), The Exmouth Integrated Artificial Reef (recreational fishing) and the Exmouth Navy Pier (diving tourism). At the suggestion of the steering committee, we also included a fifth case study, the Busselton Jetty, an iconic MMS in South Western Australia which is used for tourism, recreational fishers, divers, swimmers and many other stakeholders.

Initially, we planned to undertake four face to face focus group workshops (two in Exmouth and one in each of Karratha and Onslow). Due to COVID-19 the in-depth focus groups had to change the mode of delivery halfway through: from face-to-face to an online forum. An advantage of this in this case was the ability to broaden the geographical scope of the respondents and widen the stakeholder groups involved. We conducted the two face to face workshops in Exmouth and then trialled an online platform for running the workshops virtually. By the completion of the data collection phase, we had conducted 11 workshops in total with the groups from Karratha and Onslow. For the online focus groups, we ensured that stakeholders from the O&G sector, regulators (state and federal), recreational fishers, commercial fishers, conservation, NGO and scientific community all had representation.

Online surveys collected social and economic from a broad range of stakeholders while site specific online surveys collected data from users of the Exmouth Navy Pier, The Busselton Jetty and the broader Ningaloo, Onslow and Geographe Bay regions.

It should be noted that for some of the economic analysis, restrictions on data collection unique to 2020 and caused by Covid-19 restrictions mean that some results should be taken as indicative rather than definitive. For instance, there was an initial plan to conduct a series of boat ramp surveys to collect much of the data on spatial distribution of use, but these could not be completed due to COVID-19 travel restrictions. Instead, the online survey gathered information on location of fishing and diving trips (an essential input into the site choice models). As a consequence, some aspects of the economic analysis were not as detailed as initially intended.

Figure 1: Data collection strategy.



Section 3: Methods

Overview

This project adopted mixed methods for evaluating the value of MMS, starting with a comprehensive literature review, followed by a wide-ranging number of primary data collection exercises. The latter were particularly important, as the literature review revealed that there has been relatively little primary data collection focused on MMS in Western Australia.

The primary data collection process reflected the different research approaches across the three components (Economic Value, Social Value - Group, Social Value - Individual) but were integrated together wherever possible. The survey approaches (adopted by the social value-individual and economic projects) relied on collecting data from large samples of the target population. The social surveys identified preferences and attitudes towards the MMS of interest, as well as general socio-demographic information about the respondents. Recruitment was targeted to the population of interest, which in the case of the social science surveys was primarily users of the MMS (e.g. recreational fishers and divers). The economic surveys identified details of previous behaviour (visitation rates etc.) or derived stated preferences about how a user might behave under hypothetical outcomes. Both approaches gave insights into how and why MMS might bring value to respondents but do so in different framings. The target populations were however often the same, and in that case the design attempted to achieve synergies across the two approaches. Thus, those who completed the main "social" survey were then invited to complete the "economic" survey, allowing a sharing of recruitment costs, and basic socio demographic information. Where the economic analysis required a targeted approach to a population using a specific MMS (i.e. the Busselton Jetty) it was possible to pass respondents through to complete the social survey as well so that complementary information could be collected for all groups.

The social values-group took a different approach, in that it required in-depth engagement with a smaller number of stakeholders (the social and economic surveys took 15-20 minutes to complete, while the group approaches could take up to 3 hours). Recruitment processes differed for this approach: key stakeholders were identified and invited into the process. However, this intensive approach was targeted at the same case study sites as the economic approach, and insights from the literature review were used to help frame the group discussions.

All primary data collection approaches in this project were approved from the Curtin University Human Ethics Committee (HRE2019-0465).

Integration of online surveys

Seven survey questionnaires were developed, each targeting different user groups and/or case sites (Figure 2). The "social value - individual MMS user survey" collected data on the use, perceptions, and social values of multiple users of MMS (e.g., recreational fishers, divers, others) in Western Australia. Within this survey, respondents were asked to assign themselves to one of four stakeholder groups, i.e., recreational fisher, diver, other, or commercial, based on which they thought was the most relevant grouping for them. They were then directed to questions relevant to their selected group. Divers were defined as divers, snorkelers and free divers that do not engage in extractive activities. Recreational fishers were defined as fishers that fish for recreational purposes independent of the fishing technique/gear used. As such, spear fishers were classified recreational fishers. If respondents indicated that they were either recreational fishers or divers, they were forwarded to the "Economic random utility survey" which collected data on the use values of MMS

(relevant to their activity) on multiple sites in Western Australia. The surveys "Busselton Jetty individual travel cost survey" and "Navy Pier zonal travel cost surveys" were designed to collect data on the economic use values for users of these single sites. At the end of these surveys, respondents had the option to participate in the "social - individual MMS user survey" and the "economic random utility survey". Commercial fishers in Western Australia were asked about their use, perceptions, and social values for MMS in the "social - individual commercial fishers survey" and about their business revenues associated with MMS in the "economic commercial fishers survey". The "rigs-to-reefs discrete choice experiment survey" targeted the WA public and elicited economic non-use value associated with potential rigs-to-reefs programs and the publics' social license to operate for O&G companies to implement such programs in WA. The recruitment process for each survey is summarised in Table 1.

Figure 2: Distribution, sample and assessed values/information of online surveys from the economic component (green) and the social value - individual component (blue).

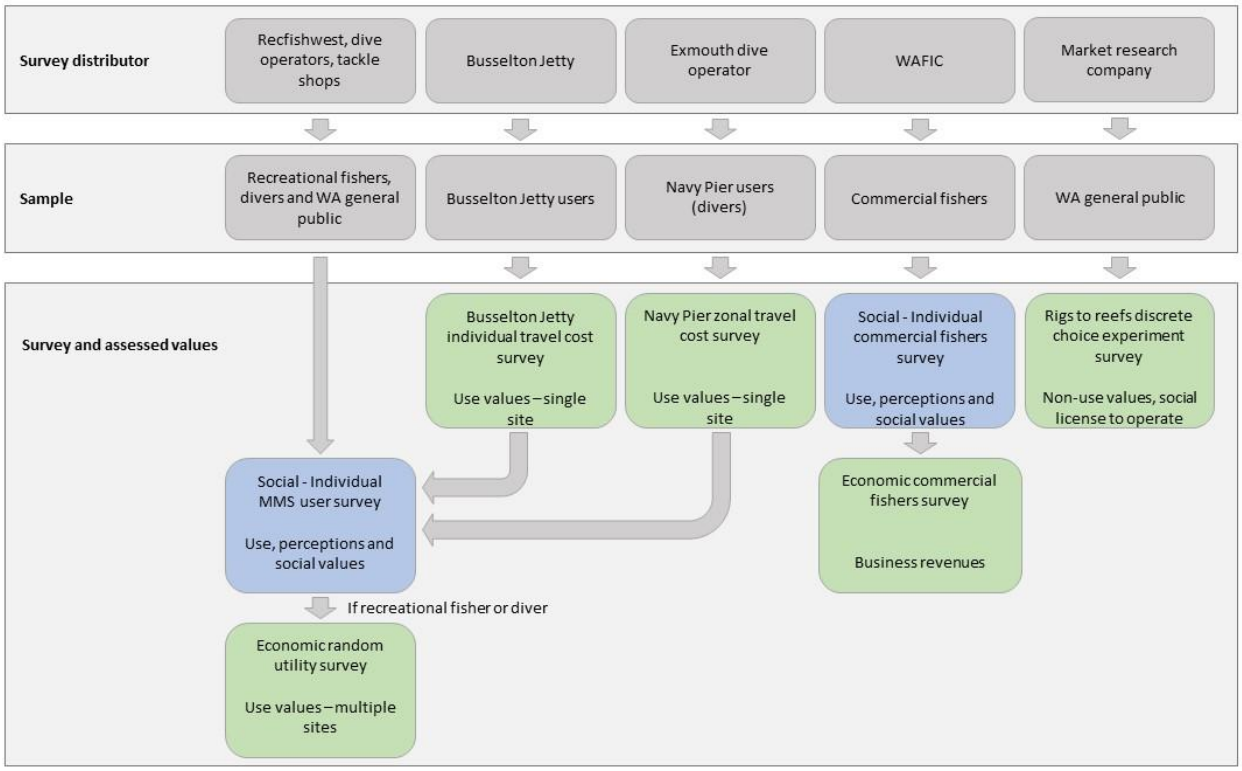


Table 1: Recruitment strategy and data collection period for online surveys.

Survey	Distribution	Data collection period	Incentives
Social - Individual MMS user Survey **Economic random utility survey**	• Recfishwest monthly 'Broadcast' newsletter (Dec 2019 and Jan 2020) • Recfishwest Facebook page and Instagram posts (Dec 2019, Jan 2020 and Feb 2020) • 500 flyers and 100 posters mailed to 40 dive and tackle shops across all four WA fishing regions • Forwarded from Busselton Jetty and Navy Pier travel cost surveys	Nov 2019 - Mar 2020	Prize draw for $750 AUD (social) Prize draw for $50 AUD (economic)
Busselton Jetty individual travel cost survey	• Busselton Jetty newsletter and social media posts • 500 flyers at Busselton Jetty entrance and museum	May - Sep 2020	Prize draw for $50 AUD
Navy Pier zonal travel cost survey	• Exmouth dive operator emails to past clients • 500 flyers at Exmouth dive operator	May - Sep 2020	Prize draw for $50 AUD
Social - Individual commercial fishers survey **Economic commercial fishers survey**	• WAFIC email to commercial fishers in Western Australia	Feb - Mar 2020	N/A
Rigs-to-reefs discrete choice experiment survey	• Market research company to WA general public	Mar 2020	N/A

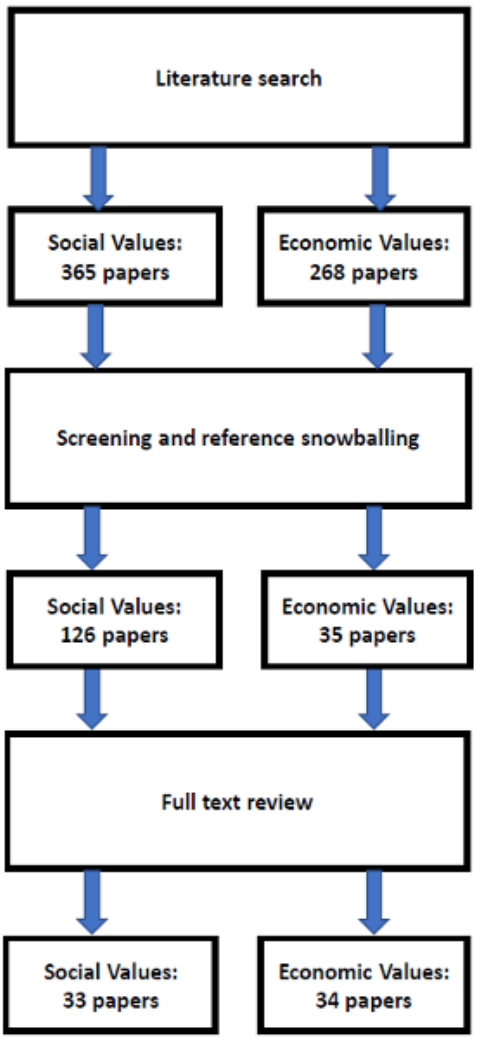
Method: Systematic literature review

A systematic review of literature exploring the topic of socioeconomic values and MMS was conducted between June and September 2019. For full details on the methodology of the literature review, see "Socioeconomic values associated with man-made aquatic infrastructure academic literature review" in Appendix 2.

Web of Science, Scopus and Google Scholar databases were searched using synonyms for 'economic value', 'social value', 'man-made marine structure', 'structure user' and 'structure objectives'. These terms were based on existing literature and recommendations from technical experts. The review also drew upon a recent National Environmental Science Program (NESP) report that explored the economic value of artificial reefs as a reference source (Blackmore et al, unpublished).

The initial search returned a total of 633 articles, 365 of which focused on social values of MMS and 268 addressing economic values (see Figure 3). All articles' abstracts were then screened to include only those papers published in English from reputable academic, government or professional organisations with a clear focus on social or economic values of MMS, and whose full texts could be accessed via the authors' institutions. This resulted in a set of 117 papers which were then searched for additional references that met the above criteria, yielding a final total of 161 papers. All of these were subject to a full text analysis to identify papers that provided detailed information on specific social or economic values which could be attributed to a user group or MMS type, resulting in a final suite of 67 papers.

Figure 3: Literature review process.



The 33 papers detailing social values of MMS were analysed to extract information on the country and year of study; MMS types; stakeholder groups; methods of stakeholder engagement; methods of social value assessment; and findings in relation to social value by stakeholder groups. The concept of social value is diffuse and context-specific, with many different approaches adopted to characterize and measure the values held by stakeholder groups. Thus, research themes covered within the social literature were identified via an inductive approach, listing the social value research question of each paper, and collating into research themes. Three core themes were identified: (i) social values; (ii) perceptions; and (iii) use and behaviour. Social values are those values that people hold arising from the use (e.g. both direct and indirect use) and non-use (e.g. the existence of marine life) of man-made marine structures. Perceptions, reflecting an individual's understanding or interpretation, will shape and be shaped by individual values. Use and behaviour refer to the drivers of MMS usage (eg recreational, commercial) and the basis on which these are used (daily, monthly etc). Sub-themes were also constructed, where relevant, to capture further variation in research focus.

The 34 articles examining economic values of MMS were analysed to identify the country and year of study; MMS type; the measured value type(s); valuation method(s); valuation context or question; and willingness to- pay (WTP) estimate. All value estimates were converted to 2019 USD values using the World Bank Consumer Price Index for the relevant countries (available at https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG) and an online currency converter (www.xe.com).

Method: Social value - Individual

Survey design

The social values survey was designed to obtain information on:

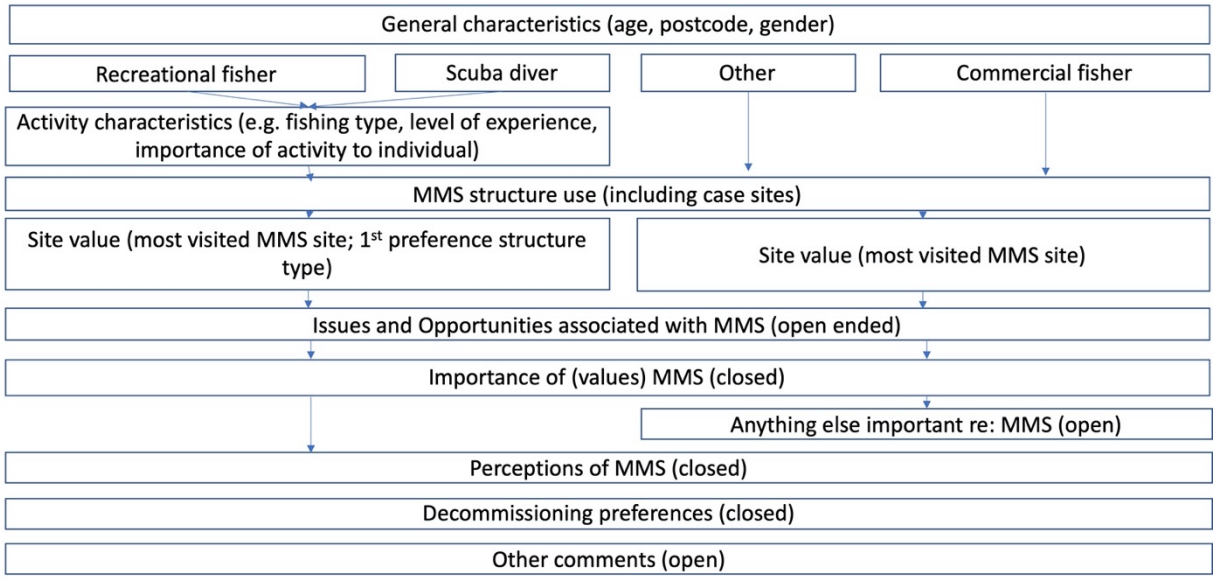
- characteristics of the respondent (e.g. age, gender, postcode).
- respondents' use of MMS.
- perceptions of MMS, involving the perceived social, economic and environmental opportunities and issues associated with MMS.
- the social values derived from respondents' use of MMS.

The survey contained both quantitative (closed response, multiple choice, Likert scale) and qualitative (open-ended) questions and was designed to be completed online in no more than 15 minutes.

Four surveys were developed, each targeting different user groups comprising (i) recreational fishers; (ii) recreational divers; (iii) other direct and indirect users; and (iv) commercial fishers. The rationale for four distinct surveys was to ensure that the questions relating to values (relational, subjective, and material) were appropriate with respect to the way the different users interact with MMS. As such, the questions were not in all cases consistent across stakeholder groups. The recruitment strategy for users (i) to (iii) was consistent; while an alternate recruitment strategy was adopted to target commercial fishers (see Table 1 above). The surveys are presented in Appendix 3.

The design of each survey was informed by the literature review, with initial questions covering respondent characteristics (age, gender, postcode), and asking respondents to self-allocate as a recreational fisher, diver or 'neither recreational fisher nor diver' (referred to herein as 'Other') to direct them to the appropriate target survey. While divers were defined as divers, snorkelers and free divers who do not engage in extractive activities, recreational fishers were defined as fishers that fish for recreational purposes independent of the fishing technique/gear used (hence, including spear fishing). Once within the target survey, questions gathered information on the respondent's level of experience with and importance of the chosen activity (e.g., diving or fishing), before asking questions relating to the three aspects of the social well-being framework: material, relational and subjective (refer to Figure 4 and Table 2 for example). The objective was to gather information on: (i) the range of subjective, relational, and material values users derive from MMS, and the importance of these values to each user group; (ii) users' perceptions of MMS, in particular their perceptions of the contribution of MMS to social, economic, or environmental outcomes; and (iii) MMS users' views on O&G decommissioning options.

Figure 4: Survey flow.



Five-point Likert scale questions were applied to gather information on respondents' perceptions of MMS (ranging from strongly disagree to strongly agree) and the values they derive from MMS (ranging from not at all important to extremely important). A constraint of close-ended surveys arises when seeking to cover a complex issue through the use of short (i.e. to reduce time constraints), simple (i.e. understood by a diverse audience) and clear (i.e. no ambiguity in terms) questions. To achieve this, the questions relating to social values were designed specific to the target user group and were therefore not consistent in all instances. In addition, respondents had the opportunity to describe via open-ended responses the benefits and limitations (social, economic and environmental) of MMS in Western Australia. In this way, further information on values and perceptions that could extend the closed response questions designed to address aspects of the social well-being framework, were gathered.

Table 2: Example of the alignment between conceptual model of social values and survey questions.

Value category	Micro-scale	Macro-scale	Meso-scale
M: Material (income, equipment, assets)	***Values: General*** Independence to choose when or how I access (R/M) ***Values: MMS Site Specific*** Value attributed to quantity of fish caught at location X	***Perceptions*** MMS contribute to local tourism MMS provide employment opportunities in the local community ***Values*** Contribution of MMS to the local economy (S/M)	
S: Subjective	***Values: General*** Fishing around MMS Diving around MMS Memories or souvenirs collected (S/M) ***Values: MMS Site Specific*** Fishing/diving at location X Species at location/visual experience of location X	***Perceptions*** A central point of identify for local communities ***Values*** Contribution of MMS to local community identity (S/R)	***Perceptions*** Structures sustain and increase fish populations and other marine life over time ***Values*** Contribution of MMS to ecosystem health (mac/mes)
R: Relational (social connections, status, management)	***Values: General*** Talking to friends or family about my fishing/diving experiences Social connections I have made	***Perceptions*** Sites of conflict between different user groups (R/S) ***Values*** Unrestricted access (M/R)	***Perceptions*** Existing management controls allow for the sustainable use (R/M)

Finally, respondents were asked their views on decommissioning and whether, when O&G facilities come to the end of their operational life, they should be:

- Totally removed and scrapped/recycled.
- Totally or partially removed and made into an artificial reef after being rendered physically stable and environmentally safe.
- Left where they are after having all oil/contaminants removed.

Survey analysis

Analysis of the survey responses was conducted to ascertain the following:

1) The level of use of MMS in Western Australia, by MMS structure type (jetties, O&G structures), and for select case study sites.
2) The values users derive from MMS in Western Australia and the relative importance of those values.
3) Stakeholders' perceptions of MMS.
4) Stakeholders' preferred options in relation to decommissioning of O&G infrastructure.
5) How values and perceptions differ depending on the types of MMS used by respondents.
6) Whether different stakeholder groups hold divergent or convergent values and perceptions of MMS.
7) The degree of variance within stakeholder groups regarding the importance they assign to values derived from MMS and their perceptions of MMS.

The intention was to generate an understanding of use, perceptions, and values at the State level, before exploring the drivers of variation within and between stakeholder groups. The first step involved data cleaning (removing duplicates and/or incomplete responses). The survey questions that were compatible across the four surveys were then linked. For example, questions relating to perceptions of MMS were consistent across the four surveys and were 'matched' to enable comparative analysis across stakeholder groups. Similarly, questions relating to the use of different MMS structure types and case sites were largely consistent across the user groups (with different terms applied to capture Thevenard Offshore O&G and some options removed where not applicable to the user group; for example, recreational fishers are not permitted to access the Exmouth Navy Pier). Finally, the questions relating to social values that were comparable across the groups were aligned, where possible. The full survey response dataset is available electronically at https://wamsi.org.au/research/programs/frdc-man-made-structures/.

The survey did not require respondents to name individual MMS that they used, as it was felt this would add considerably to the time required for respondents to complete the survey. Consequently, analysis of responses was undertaken to identify categories of MMS usage in the last 12 months. This generated five categories comprising 1) jetty and/or pier users only; 2) offshore MMS users only; 3) combination of onshore and offshore MMS users; 4) users of all MMS; and 5) non-users. For instance, if a respondent noted that they had visited piers and jetties within the last 12 months, but no other form of structure, they were categorised as 'jetty and/or pier users only'; whilst if they had only used artificial reefs, they were categorised as 'offshore MMS users only'.

To explore the drivers of within and between group variation in perceptions and values, chi-square cross-tabulations and ordinal logistic regression analysis was performed in SPSS. In the first instance, differences in the ratings assigned to each value and perception statement by user group (i.e., recreational fisher, diver, other, commercial fisher) were considered. Pearson chi-square tests with P values <0.05 were defined as a significant level of difference and further analysis of the factors contributing to variation were explored via ordinal logistic regression.

Ordinal logistic regression can operate with categorical and ordinal values. However, respondent age was captured over nine age categories following ABS standard classifications. To facilitate data analysis, three generational age groups were constructed from the base data: 'Generation Y': 15-39 years, born 1980-994; 'Generation X': 40-54 years, born 1964-1985; and 'Baby Boomer': 55+ years, born 1946-1964. In addition, 'unsure' responses were removed. Any 'unsure' responses to values and

perceptions questions were automatically coded 6 (as they were the last option within the multiple-choice question) and therefore had the potential to be processed as of 'highest value' or 'most agreement', respectively within ordinal regression. We chose to remove these rather than reclassify unsure responses as 'neutral', as a neutral option was made available to respondents.

The ordinal logistic regression provided an understanding of the extent to which the independent variables explain the response to the value or perception statement. Positive coefficients imply that higher values of the independent variable will increase the probability of a 'higher' scored response. Significant relationships are evaluated on the basis of the p value for the individual coefficients. The overall significance of the model measures the joint contribution of all independent variables (based on a chi squared test comparing the fitted model with one that only has a constant: reported as Model Fitting Sig.). There are several measures of goodness of fit: we report the Pearson test, which assumes that there is a congruence between the observed answers and those predicted by the model, for the categories of the independent variables. Significance values greater than 0.05 imply a failure to reject the null of a good fit.

Open-ended responses to the questions on the social, economic, and environmental benefits and issues associated with MMS were imported into NVIVO and inductively coded. Also referred to as open coding, inductive coding creates codes based on the qualitative data itself and does not draw on a framework to inform the approach to coding. While the alternative deductive approach was considered, using the social-wellbeing framework as a tool to structure coding of the open-ended responses, it was deemed appropriate to adopt an inductive approach to enable movement beyond the framework that informed data collection through the closed survey responses.

Responses to the Busselton social survey were analysed separately from the State-wide surveys. The focus was on obtaining site-specific information on values and perceptions, as well as use levels. As such, values were confined to micro-scale, site-specific values, focusing on the subjective and relational values relevant to recreational fishing, diving, and other user groups.

Method: Economic value

The total economic value

In the context of MMS, one can categorise values into three broad types (Table 3).

Values arising from direct use (i.e. those that require some interaction with the resource of interest, e.g. through fishing, diving, tourism).

Indirect values, which are values that may accrue through the presence of the resource, but which does not involve direct involvement with it (e.g. coastal protection from habitat improvement, and in our case we extend this to include multiplier effects on local economies from expenditure arising from direct use).

Non-use or existence values, which people may hold for the environment, but without the need to directly interact with it (e.g. the value gained from knowing that an ecosystem/species exists and is maintained).

Table 3: Total Economic Value (adapted from Whitmarsh et al. 2008).

Total Economic Value		
Direct Use Values	**Indirect Use Values**	**Non-Use Values**
Benefits arising from the immediate use of a MMS in the form of outputs that can be consumed or enjoyed directly. **Examples:** Extractive uses (e.g., commercial, and recreational fishing, offshore aquaculture) Non-extractive uses (e.g., diving and surfing tourism)	Benefits that a MMS provides to support other economic activities, or positive externalities that affect other users of the marine environment. **Examples:** Fish production via habitat protection (e.g., seagrass). Effort diversion from overexploited fisheries or dive sites. Coastal and shoreline protection. Water quality improvement via nutrient removal	Benefits from knowing that a marine asset has been conserved (existence and bequest/altruistic values) or may be available for use later (option value). **Examples:** Knowledge that reef-based protection has increased marine biodiversity Knowledge that a unique habitat is conserved intact for future generations

Values can be differentiated into 'producer' and 'consumer' surplus. Producer surplus (PS) is synonymous with profit e.g., the profit earned by commercial fishers, or those providing accommodation to recreational users of MMS. Consumer surplus (CS) accrues to those who enjoy the outcomes of the economic activity i.e., those who purchase the fish, (or recreational experience), and is a measure of the value of those goods/activities to the end user.

It is important to distinguish between consumer surplus and expenditures. Expenditures are the costs that users of MMS incur when participating in some activity associated with MMS (e.g., a fisher expends money for bait at local tackle shops, or a consumer purchases fish). Although direct

expenditure is often taken as a measure of the value of an activity, this is strictly not the case. It gives no indication of the level of consumer benefit that may be enjoyed (e.g., some shore based recreational fishing may have high value to the fisher but involve negligible expenditure). It overstates the community benefits (e.g., to those who supply goods/services consumed), as strictly it is the profits that are earned from this expenditure that is the benefit to society. However, the aggregate expenditure or jobs created, are often used instead as a proxy.

However, those who participate in activities gain additional value, over and above the expenditure they have incurred. It is this additional value that is defined as the consumer surplus (or 'welfare' or 'utility'). The consumer surplus can originate from activities directly or indirectly associated with an MMS (CS from the direct or indirect use), or from the existence of MMS (e.g., an improved environment), independent of any activity on MMS (i.e., CS from non-use, also called "existence value"). Although this value can be considered as a 'psychic' phenomenon, there exist methods by which it can be quantified in monetary terms and the use of these values is increasingly accepted in policy evaluation (for example see Bateman and Kling, 2020, for an overview of their use in the UK, EU, and USA).

Economic valuation approaches

There are a variety of economic valuation approaches to estimate particular economic value types, or the total economic value of MMS. These can be broadly categorised into approaches applied in the absence of primary data and with primary data collection taking place. The former is the "benefit transfer approach" that uses previous data and literature to assess the value of MMS. The latter contains numerous valuation techniques. Here we applied approaches that focus on the use values of single sites, the use values of multiple sites as well as on the non-use values associated with MMS.

Economic values in the absence of primary data: Benefit transfer

In the absence of primary data collection, economic use and non-use values can be quantified using the benefit transfer approach. This was done by estimating a demand curve using information on:

- The size of the population that uses the structure per user group.
- The frequency of trips to the structure in a given time frame (i.e., the last 12 months).
- Economic benefits associated with the structure and/or the activity on the structure.

The identified information needed can be collected from a variety of different sources. Economic data such as the expenditure and consumer surplus measures are regularly available in scientific or grey literature as well as data from governments. For the most reliable results, the numbers used are as closely related to the case study as possible. Factors that can be taken into consideration to check for the applicability of values take into consideration the geographic proximity and the cultural and economic context of the location, the year of data collection, the target species, and the quality of the research or information. In the case that not all the needed data are readily available from existing literature and online sources, the missing information can be gathered through interviews or focus groups with representatives of stakeholder groups.

The benefit transfer approach allows for the estimation of both, use and non-use values, depending on the availability of the information in the literature. Whether a study has assessed non-use values can be identified by checking if they have: (i) used a non-market valuation technique (e.g., discrete choice experiment) and (ii) have sampled the population that does not necessarily use the MMS directly or indirectly (typically the general public). It is important to notice that non-market valuation techniques can measure both use and non-use values. The consumer surplus measure from the literature is then aggregated over the relevant population of the case studies.

We developed an assessment framework to estimate the economic value for two case studies:

1) O&G infrastructure around Thevenard Island off Onslow which are potential future artificial reefs for a range of different end-users. Values were estimated for two different decommissioning scenarios: i) leave existing O&G structures in place and ii) repurposing parts of the material for new artificial reefs (Appendix 4).
2) The Exmouth Integrated Artificial Reef (EIAR) is an existing artificial reef which allowed us to evaluate some pre- and post- data on ecological conditions, and there were relatively good (although still limited) data on recreational fishing activity in the relevant area (Appendix 4).

There is an ongoing discussion about the capability of artificial reefs to produce new biomass vs attracting biomass from surrounding areas (Bull and Love, 2019). The generation of new fish biomass increases the catchability and/or the number of fish to be observed on the artificial structure while maintaining the condition in the surrounding areas equal. Conversely, the attraction of biomass from surrounding areas re-distributes the existing biomass and can increase the catchability on the artificial structure but might decrease the catchability in the surrounding areas (Pickering and Whitmarsh, 1997).

Moreover, there is an uncertainty about whether artificial reef users are new users in the area generating new revenues, or whether they substitute another local site with the artificial reef site. These two factors have consequences for the economic value that an artificial reef can generate. To get an understanding of the range of possible values, we applied two different approaches:

- Approach 1: Upper value

  To estimate the upper value of the possible range of the economic impact from an artificial reef, this approach assumed that there is new production of fish biomass available around the reef and that the reef attracts new fishers to the area.

- Approach 2: Lower value

  The lower bound of the value range assumed that the biomass on the artificial structure is attracted from the surroundings and that the users have been engaging in activities in the area before the creation of the structure. The creation of a new artificial reef will re-distribute efforts in the area and create economic value through lower congestion. This increase in value can attract new users to the area.

Full details of the methods applied can be found in the case study report “The potential economic value associated with the development of artificial reefs in Western Australia” in Appendix 4.

Economic use values: Single site-specific

Travel cost method

The travel cost method is used to estimate economic use values that are associated with recreational sites. The method is based on the principle that the number of trips people make, and their different travel costs reveal their willingness to pay (WTP) to visit that site (Ward and Loomis, 1986). Therefore, we can estimate not only the expenditures, but also the surplus measure associated with that site. As this method is concerned with single sites, it cannot account for substitutions among different sites. Here, we applied two variations of the travel cost method to two case studies: A zonal travel cost method for tourists diving at the Exmouth Navy Pier and an individual travel cost method for users of the Busselton Jetty.

In both cases, the valuation of economic use values required the estimation of a demand curve which needs the following information that were collected in an online survey:

- the size of the population that uses the structure per user group.
- on land and on water expenditures associated with trips to the MMS.
- the frequency of trips to the structure in a given time frame (i.e., the last 12 months).

Furthermore, the travel cost surveys asked respondents for additional information such as respondents' place of residence, the number of people in their group during the visit, substitution activities if the MMS was not available, and demographic information such as age, gender, and annual household income. In the case of the Busselton Jetty, multiple user groups are visiting the site. Therefore, we also asked them about the way respondents use or engage with the Jetty (see full surveys in Appendix 5).

Economic values were measured as the difference between the status quo and a proposed change in condition. The status quo might be the presence, the absence, or a specific state of an MMS. Consequently, the change in conditions could be that an MMS is being added, removed, or modified. In the two case studies, the MMS is already in place, hence we measured the value under the current level of usage compared to the usage under the proposed condition (e.g., an increase in entrance fees).

Zonal travel cost method for Exmouth Navy Pier

The zonal travel cost method was used to calculate the number of visits from dive tourists to the Ningaloo Region assuming that travel costs increase with distance. Different travel distances were then combined into six zones (geographic areas) around the site (in the order of increasing distance): Western Australia, other states of Australia, Oceania, Asia, Europe and America. The visitation rate from these zones was obtained based on days spent per million capita of the total population of countries where visitors came from in each zone. We fitted a regression analysis (see formula below) to the data and used the predicted model to estimate how the demand (the number of days spent) in the Ningaloo region would change if travel costs increased. The change in demand under increasing costs revealed the economic benefit (consumer surplus) that the Ningaloo region provides to visitors.

$$\ln(stay) = \alpha + \beta / TC$$

where *stay* is the total number of days that people of a certain zone stayed in the Exmouth region, *TC* is the travel cost that is needed to travel from each zone to the Exmouth region and α and βare model parameters.

Individual travel cost method for Busselton Jetty

The individual travel cost method relies on estimating a relationship between the trip frequency to a site, and the cost of accessing the site. A Poisson model is commonly used to model the data, as it reflects the count (integer) and non-negative nature of the data. However, there are several issues that have to be addressed. The Poisson model is well known to impose restrictions on the distribution of the data: the assumption is that the conditional mean and variance of the dependent variable is equal, which may not be the case. Extension to the model allows for over dispersion (a negative binomial model). Secondly, if data is collected from intercept sampling, then by definition the number of visits has to be more than one. However, we dealt with this issue by a simple adjustment: by subtracting one from all number of trips (Shaw, 1988).

A further issue arises when data is right censored: if identification of the number of trips includes a "more than x" category. However, there exists a censored negative binomial model, implemented in Stata (Hilbe, 2011).

The estimate of the consumer surplus associated with a trip is identified simply as the negative inverse of the coefficient estimated on cost.

For all details on the methodology, see the full report "The economic value of the Exmouth Navy Pier and Busselton Jetty, Western Australia" in Appendix 5.

Economic use values: Choices across multiple sites

Random utility model

We used a random utility model (RUM) to analyse to what extent MMS influences the site choice of boat-based recreational fishers and divers in four regions in Western Australia: Geographe Bay, Coral Bay, Exmouth, and Onslow region. The advantage of this approach is that RUMs can not only test how site specific and individual specific factors influence respondents' site choice, but they can also estimate the monetary value of these effects. Moreover, this method allowed us to predict the economic consequences of future scenarios (such as the removal or addition of MMS) for recreational users.

The random utility approach works under the assumption that individuals visit a specific site (out of all possible sites) because they prefer it over the others (they maximize their utility). This site choice is influenced by trade-offs between the quality of the site and the costs to travel to the site. Consequently, the RUM requires information on relevant characteristics and the travel costs for all sites that a visitor could choose.

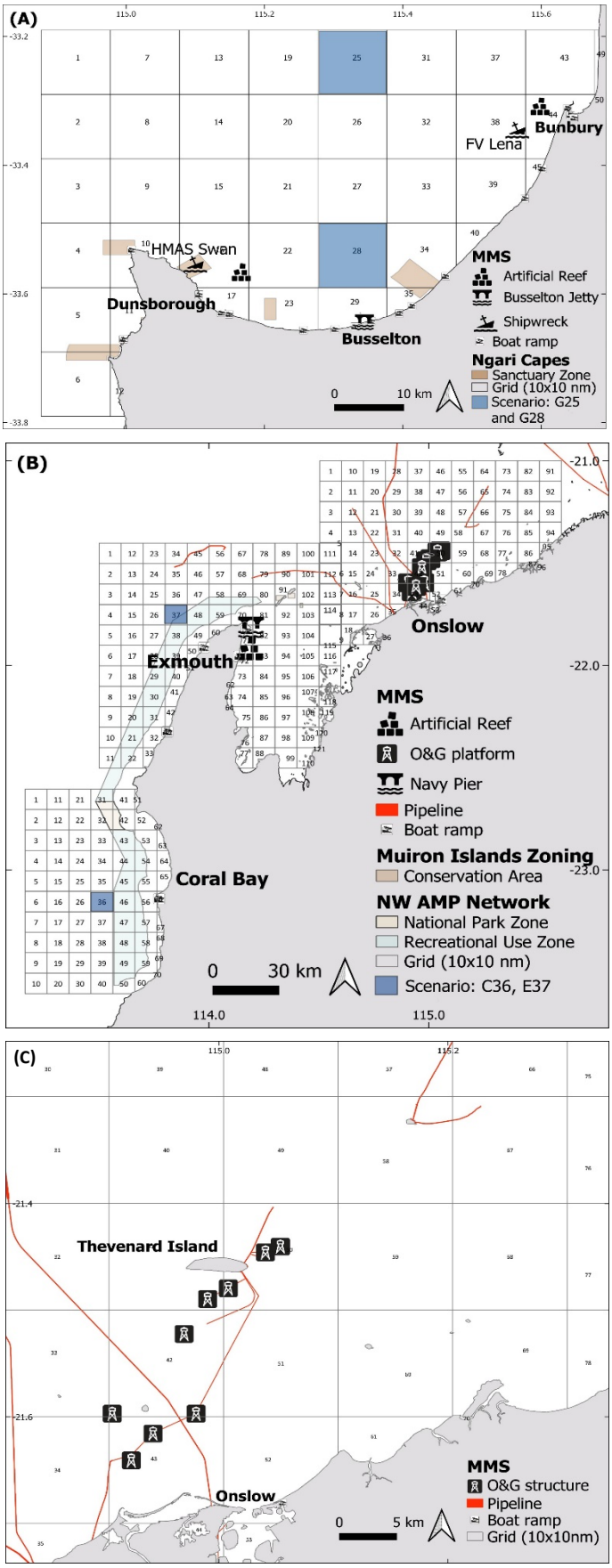
We used an online survey with recreational fishers and divers that asked about their boat-based trips in the four regions: Geographe Bay, Coral Bay, Exmouth and Onslow in the last 12 months. For each region they visited, they were presented with a map on which they could indicate the exact location that they were fishing or diving at. We also asked them about on-the-water travel distance, travel costs to arrive at the destination, other costs associated with trips, what activity was done at the site, the place of residence, demographic information and factors that determine the quality of the sites (e.g., target fish species). The full survey can be accessed in Appendix 6.

Surveys can also be collected at boat ramps within the study site or via apps that allow respondents to enter detailed information about their visits in a logbook. Due to COVID-19, this approach was not implemented in this case study.

We used a logistic regression (logit) model to test what factors influence the probability of a respondent to choose a certain location in the regions. Each choice option was one cell in a grid of 10 x 10 nautical miles (Figure 5). The limit of the grid was determined by the extent of the map shown to respondents in the survey.

Figure 5: Study regions with grid, MMS and locations where MMS were hypothetically added.

(A) Geographe Bay, (B) Coral Bay, Exmouth, and Onslow region, and (C) close-up of Onslow region.



The variables that we tested for significance were:

- on the water travel cost in AUD.
- number of MMS type per grid cell for shipwrecks, artificial reefs, jetties, and pipelines.
- mean water depth per grid cell in meters.
- distance from the shore in km.
- surface area of the grid cell in square meters.

Welfare impact of MMS

The model results of the RUM give information about how the above variables influence the probability of visitors to choose the different sites (grid cells) within the study area. Consequently, this approach is able to predict the change in site choices when conditions of a certain site change. We predicted the change in welfare for boat-based recreational fishers and divers associated with various hypothetical scenarios (Table 4) such as the removal of existing MMS as well as the addition of new MMS at certain sites (Figure 5A). We distinguished between different MMS types to measure the effect on recreational fishers and divers because they are being used differently by the user groups:

- shipwrecks in the study area are only open for access to divers.
- artificial reefs are mainly designed for recreational fishing activities but are open to divers.
- Busselton Jetty is open to both recreational fishing and diving, except for a sanctuary zone that is only open to diving.
- Thevenard O&G infrastructure is currently closed to any recreational and commercial activities.

To understand the value associated with potential diving and recreational fishing on Thevenard O&G infrastructure, we changed the structure types into either “shipwrecks” or “artificial reefs” to imitate conditions that are more favourable to divers or recreational fishers. Also, we did not consider the Navy Pier in the scenarios because it is closed to boat-based activities.

Importantly, the RUM measured the change in welfare when visitors substitute among different sites when conditions change. Therefore, the estimated change in welfare took these substitutions in account. It should also be noted that these estimates of welfare changes for the users of the MMS do not account for any costs of constructing them. They therefore represent the benefits of MMS, and could then be combined with estimates of costs within a full cost benefit analysis.

Table 4: Hypothetical scenarios describing the change of MMS at study sites.

Scenario	Description
Geographe Bay	
BJ	Remove Busselton Jetty
SW	Remove Swan Wreck
LW	Remove Lena Wreck
DAR	Remove Dunsborough AR
BAR	Remove Bunbury AR
G25	Add MMS in Geographe Bay (cell 25)*
G28	Add MMS in Geographe Bay (cell 28)*
Coral Bay	
C36	Add MMS (cell 36)*
Exmouth region	
EAR	Remove EIAR
EW	EIAR diver access only
E37	Add MMS (cell 37)*
Onslow region	
AR9	Access O&G infrastructure: 9 “artificial reefs”
W9	Access O&G infrastructure: 9 “wrecks”
AR4W5	Access O&G infrastructure: 4 “artificial reefs” (Roller A, Roller B, Cowle, Saladin A, Saladin C) and 5 “wrecks” (Roller B, Skate, Yammaderry, Saladin B)
AR2	Access O&G infrastructure: 2 “artificial reefs” (Roller B, Roller C)
W2	Access O&G infrastructure: 2 “wrecks” (Roller B, Roller C)

* *Added “artificial reefs” for recreational fishers and “wrecks” for divers*
a) Note that the MMS are assumed to be in the centre of the grid cell

For all details on the methodology, see full report “The use value of man-made marine structures in Western Australia: A random utility model” in Appendix 6.

Economic existence values: Community preferences

Discrete choice experiment

A discrete choice experiment (DCE) was designed to assess Western Australia community members’ preferences towards different policies of MMS. We applied this approach to rigs-to-reefs as an alternative option to complete removal of offshore O&G infrastructure in Western Australia. In this context, we estimated the relative values held by the community members for different attributes of rigs-to-reefs policy. We assessed community members’ attitudes towards the O&G sector by measuring their Social License to Operate (SLO) granted to this sector and estimated the extent to which these attitudes could influence their preferences among the two policy alternatives: complete removal vs. rigs-to-reefs.

Like the random utility approach, the DCE approach assumes that people make choices that maximize their utility. It also assumes that the higher the utility of an environmental good the higher their WTP, even when they do not directly or indirectly use this good. Hence, this method is suitable to measure existence (or non-use) values. In the context of MMS, non-use values reflect the value

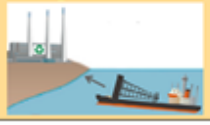
that people hold for the marine life around the structures and are willing to pay for its preservation, even when they never plan on visiting the area. This WTP depends on the characteristics of the MMS, here called attributes. Each attribute can have different levels (such as specific amounts of biomass). One of the attributes is a monetary measure (also called a payment vehicle), hence we can use the DCE to measure the WTP of people depending on different levels of these attributes. The payment vehicle in this survey was presented as the percentage of the savings that companies would make from not undertaking complete removal and would be paid out to the State budget as additional revenue. All attributes and their levels are described in Table 5.

Table 5: Attributes and levels.

Attributes	Rig-to-reef levels	Status quo levels
Total fish biomass (tonnes)	0.5, 1, 1.5	Negligible
Fish attracted vs. Fish produced	Attracted, Produced	N/A
Habitat for threatened species	Yes, No	N/A
Who can access the reef	None, Rec. Fishing, Rec. Diving	N/A
Future liability in case of any environmental damage occurring	Company, Government (taxpayer), Shared	N/A
Amount of money paid to the State budget by the company (AUD)	100 million, 130 million, 160 million	0

The DCE survey presented participants with a number of different rigs-to-reefs scenarios that are reflected in choice options in which the level of each attribute was being alternated. For each choice set, one choice option always remained the status quo level of each attribute (Figure 6). Respondents were then asked to choose their preferred option for each choice set.

Figure 6: Example of choice set.

	OPTION 1 Rig-to-reef	OPTION 2 Rig-to-reef	OPTION 3 Complete removal
			
Total fish biomass (tonnes)	0.5	1.5	Negligible
Fish attracted vs. Fish produced	Produced	Produced	N/A
Habitat for threatened species	Yes	No	
Who can access the reef	Recreational Fishers	Recreational Divers	
Future liability in case of any environmental damage occurring	Government (taxpayer)	Government (taxpayer)	
Amount of money (AUS) paid to the State budget by the Company	160 million	100 million	0

Additionally, the survey measured the SLO of respondents by asking respondents for their attitudes towards the conservation of the marine environment and the O&G industry. The questions followed the approach by Boutilier and Thomson (2011) which identifies four increasing levels of SLO: economic legitimacy, interactional trust, socio-political legitimacy, and institutionalized trust (Table 6). Finally, respondents were also asked debriefing questions regarding their choices, and demographic information. For the full survey, see Appendix 7.

Table 6: Description of levels of SLO (Source: (Boutilier and Thomson, 2011))

SLO Level	Description
1. Economic legitimacy	Refers to the perception of economic benefit from the company.
2a. Socio-political legitimacy	Refers to the perception that the well-being of the region can be improved by the company.
2b. Interactional trust	Refers to the perception that the company is involved in mutual dialogue with the community and demonstrates reciprocity.
3. Institutionalised trust	The highest level of SLO that can be achieved by a company and refers to the perception that relations between the community and the company are based on the consideration of each other's interests.

The data generated by the DCE were analysed by statistical models that measured the preferences for the different policy scenarios. The analysis provides information about the effect that each level of each attribute has on the preferences and the WTP of respondents.

For all details of the methodology, see the full report "Community acceptance of rigs-to-reefs in Western Australia" in Appendix 7.

Method: Social value - Group

Focus groups

A series of focus groups were undertaken to complement the survey data elicited from the social value: individual activity. These were designed to allow for participants to surface *deep* (reflecting nuanced, elaborated data capture) and *systemic* (reflecting the presence of interactivity between elements) information. This would allow for a more fine-grained appreciation of the varying values surrounding MMS. In addition, the focus groups were designed to enable participants to gain an *increased awareness and understanding* of the range of issues, opportunities and values surrounding MMS. Other guiding factors taken into account included:

- ensuring capture of contemporaneous data (rather than relying on historical and possibly outdated information).
- attending to context (reflecting the varying impacts/appetites of different geographies).
- addressing a wide range of perspectives i.e., different cohorts of stakeholders (ensuring breadth of view).

The focus group workshops comprised a mix of ‘in person, face to face’ and 'online’ groups, due to COVID-19. Each focus group was targeted to a particular cohort (stakeholder group) including community groups (Exmouth, Busselton, Karratha, Onslow), regulators (federal and state), fishing (commercial and recreational), O&G companies and NGOs. Eleven workshops were run from October 2019 to August 2020, involving a total of 64 participants, with an average of six participants per workshop. The majority of the participants were from Western Australia, however, the Commercial Fishers workshop had one participant from the Northern Territory, the Recreational Fishers’ workshop had participants from Victoria, the Northern Territory, Queensland, and New South Wales and the second Regulator 2 workshop had three participants from Canberra. See below Table 7 for details.

Table 7: Dates and participants of workshops.

Workshop (broader classification of attendees)	Workshop Date	F2F or Online?	Participants
Exmouth 1 (Industry, conservation, private sector, local government)	15/10/2019	F2F	7
Exmouth 2 (Industry, conservation, private sector)	16/10/2019	F2F	8
Chevron (Industry)	23/04/2020	Online	4
Regulator 1 (State and federal government)	18/05/2020	Online	4
Oil & Gas (Industry)	21/05/2020	Online	5
Regulator 2 (State and Federal government)	22/05/2020	Online	8*
Recreational Fishers (Private sector, research, industry)	09/06/2020	Online	6*
Karratha & Onslow (Private sector, local government)	24/06/2020	Online	4
Busselton (Private sector, research, conservation, industry)	14/07/2020	Online	4
Commercial Fishers (Industry, private sector, conservation)	21/07/2020	Online	7*
Non-Government Organisation (Industry, conservation)	12/08/2020	Online	7
Total:			**64**

*participants joining from places other than Western Australia.

The rationale for conducting stakeholder cohort-oriented focus groups was that it would be possible to identify any cohort idiosyncrasies and subsequently analyse the data to reveal the extent of homogeneity/ heterogeneity of view both between and within cohorts. Thus, it would enable those making decisions to appreciate the diversity (or not) of perspective and be able to design policies and actions accordingly. Attendees were selected based on personal contacts, recommendations, and to ensure diversity of view using a purposive sampling method (Miles and Huberman, 1994).

The design

The process adopted followed a well-established modelling process which allowed for a structured conversation (Ackermann and Eden, 2011a, 2011b). Each focus group workshop, regardless of mode (face-to-face or online), followed the same design (to ensure comparability) and lasted between 3 to 3.5 hours. The rationale for the selected length of time was to balance busy diaries with being able to capture and explore the emergent material in a comprehensive fashion.

Each focus group workshop began with an introduction to the research objectives, and a review of the agenda, providing participants with a clear outline of how the focus group would unfold. After a brief explanation of mechanics associated with the Group Support System used, all the workshops commenced with participants being requested to surface the issues and opportunities that they felt underpinned MMS. This focus was selected as prior research experience has shown that it is often difficult for individuals to identify the values that drive their behaviour (those 'in action') - instead participants provide values that are 'espoused' (Ackermann and Eden, 2011a). Research has also showed that a less than complete set of values is obtained by simply asking for values. Starting with issues and opportunities enables participants to tease out values 'in action' as issues are only issues if they potentially 'challenge' a desired outcome. Likewise, opportunities provide the basis for eliciting 'aspired for' or valued futures.

In addition, it was believed that by eliciting a wide range of issues and opportunities, decision makers would be better positioned to arrive at *robust* (capitalising on the range of expertise) and *acceptable* (attending to social justice considerations) policies and actions. Identifying both would allow issues to be considered and managed and opportunities capitalised upon when considering any new infrastructure.

To enable as wide a range of views to be captured, in an authentic manner, individuals were able to *enter their issues and opportunities anonymously and directly* via laptops (in the face-to-face workshops these were provided, in the online workshops participants used their own devices). This process ensured that the contributions were captured as the participants viewed them (that is, in their own language) rather than risk being changed through a facilitator paraphrasing them. It also ensured all the views were captured and not lost. Allowing participants to anonymously contribute the issues, opportunities and values directly helps reduce conformity pressures allowing for more wide-ranging views to be captured. It also enables each participant to speak 'simultaneously' enabling an increase in productivity (Ackermann, 2020). In addition, the process enables a breadth of material to be captured, avoiding the constraints imposed by surveys which frequently present a list of options from which to choose. See below Figure 7 for an example of a group using the face-to-face mode and below that see Figure 8 for a screenshot of what on-line participants experienced.

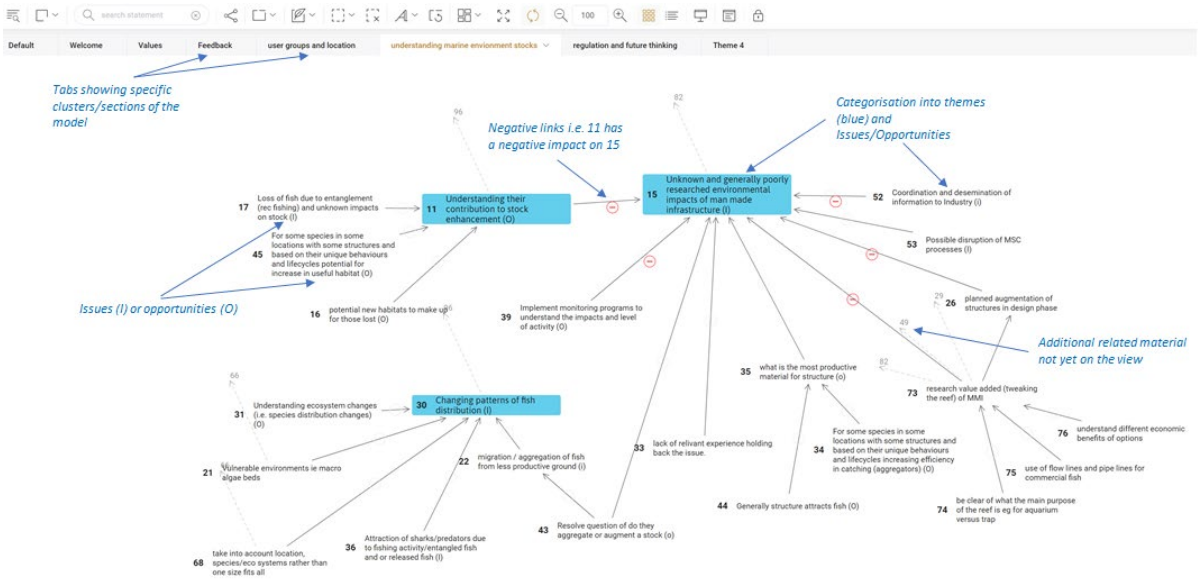
Each participant was able to see their own material and that of others as it was generated. This both enables the prompting of further material (participants can piggyback off one another's contributions) and digestion of others' contributions (avoiding immediate physiological responses and allowing more thoughtful consideration). As such participants were able to immerse themselves in the wide range of views and gain a deeper appreciation of the issues and opportunities surrounding the topic.

During the generation phase, contributions were clustered according to content by the facilitator. This aided the navigation of the material as typically over 50 statements were captured in a very short time and by clustering the material, it is possible to manage the unfolding complexity. Once participants had surfaced all the issues/opportunities that came to mind, a review of the clusters was undertaken. The review enables:

- a check to ensure contributions are in the most appropriate cluster (it is not untypical for contributions to be able to 'fit' in >1 cluster and so determining the most appropriate helps with effective positioning as well as prompting further conversation).
- each contribution to be checked for comprehension by all - sometimes resulting in the wording requiring further elaboration to ensure a shared understanding.
- the generation of new material as meaning is discussed promoting further thoughts.
- the ability to determine 'themes'.

Figure 7: Group using Group Explorer at FRDC workshop.

Figure 8: Online view of material being surfaced and structure using Strategy Finder.



Note participants on their laptops were able to see each statement as it was entered (but not who said it), take part in the clustering and linking process, identify themes and values. At the top a number of 'tabs' were created allowing particular chunks (e.g., themes, the value system) to be viewed. Participants could move between them whenever they liked.

The next step was to explore the systemic impacts between the issues and opportunities. This constitutes identifying connections between contributions in the form of causal links (chains of argument) reflecting that issues impact other issues and opportunities. This linking process enables the creation of a network - a directed graph - further assisting with the development of shared understanding, revealing systemic properties, and facilitating analysis. Recognition of the interactivity of issues and opportunities emerges early in the cluster review process as participants provide explanations as to why a statement should be in one cluster or another. The process of linking also reveals that issues and/or opportunities can impact more than one value illustrating multiple ramifications and potentially uncovering potent opportunities (supporting >1 value) or risky issues (having multiple negative consequences).

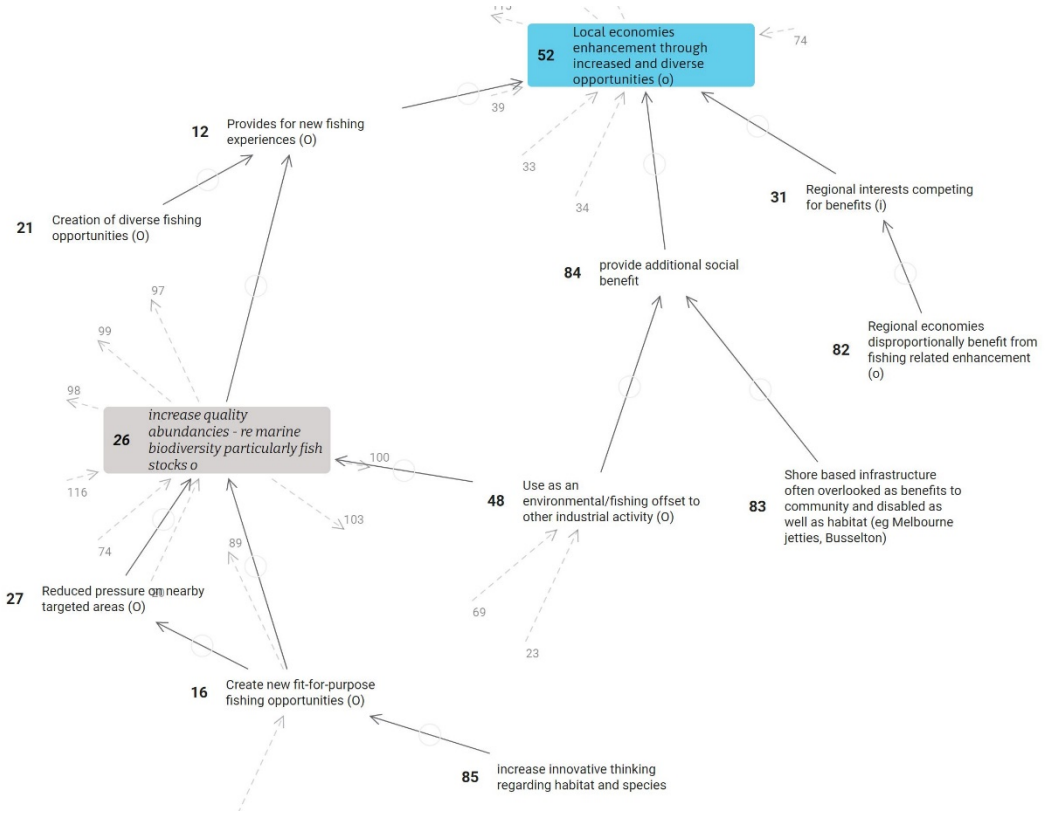
The process of exploring the impact of contributions on one another:

- facilitates the prompting of further material as participants are exposed to the thinking of one another and how they perceive the world and as such participants respond to differences in opinion by teasing out alternative chains of argument.
- enables the building of a deeper understanding of the topic as issues and opportunities are seen in context.
- assists the group to move from divergence to convergence attending to the objective of increasing awareness.

Below is a small excerpt of material (reflecting the statements and their relationships) from one of the focus groups (Figure 9). The arrows are read as causal links that allow *chains of argument* to be constructed. For example 16 *create new fit for purpose fishing opportunities*, may result in 26 *increase quality abundance* which in turn may enable 12 *provide for new fishing experiences*. The numbers appended to each statement allow the data to be easily identified and managed and have no ‘value’ associated with them.

As participants were asked to note whether the contribution was an issue (I) or opportunity (O) the general complexion of each cluster could be determined i.e. was it dominated by issues or opportunities or a mix. It was also possible to categorise the material using styles - with blue boxes representing themes and grey boxes representing values. This aids with navigation as participants can easily see the status of each contribution.

Figure 9: a small section of a causal map.



Note: The statement at the top of the hierarchy is a 'theme' (blue) and an opportunity (O). Supporting it are three chains of argument plus information noting the fact that there are a number of other statements, not displayed on the map at present (but whose presence is shown through the dotted arrows e.g., 33). The software, a relational database, allows the users to view as much or as little material as is helpful and useful and a range of views displaying user defined maps can be created. The numbers have no 'value' – they are tags to allow each statement to be managed.

For all the workshops aside from the commercial fishers' workshop (due to time pressures) to conclude the issue/opportunity generation phase, participants were asked to prioritise (again using the direct entry anonymous process) the emergent clusters. For the face-to-face groups they were able to allocate preferences reflecting importance and likelihood. For the on-line workshops, each participant was able to rate the themes according to importance. This prioritisation provided an insight into the degrees of convergence of thinking (how much agreement there was within the cohort) and preference (which of the themes received the highest average rating). The results were reviewed with the group and discussed. A brief tea/coffee break was then provided.

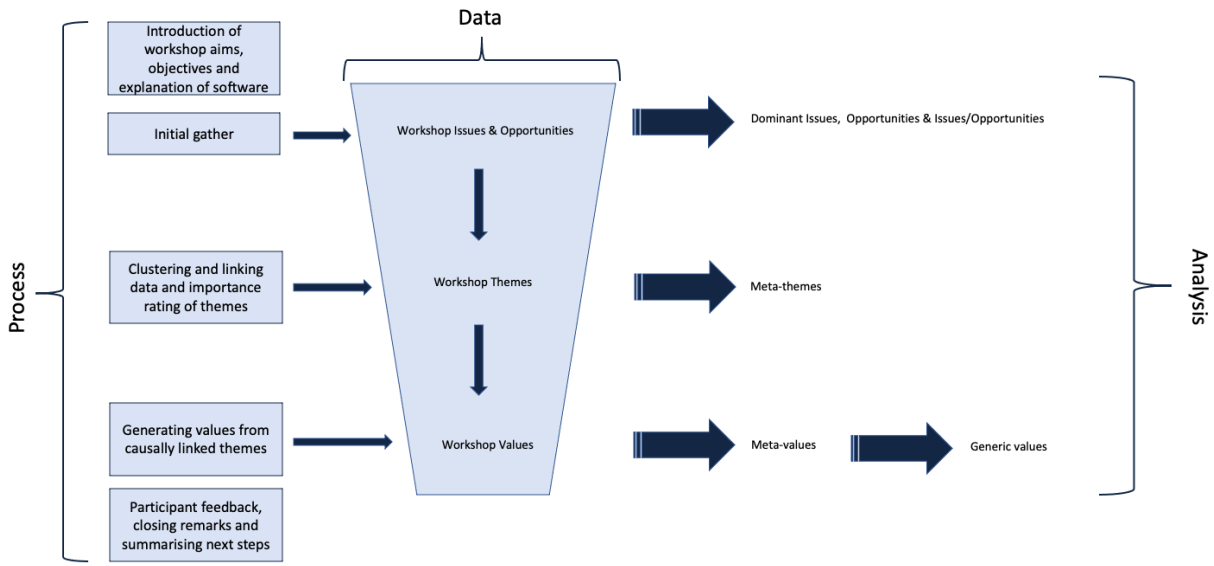
The final session of the workshop concentrated on using the clusters of issues and opportunities (themes) to identify emergent values. As noted above, the logic is that participants perceive something to be an issue because it is implicitly adversely affecting something valued (likewise it is an opportunity if it enables the achievement of something desired/valued). This process:

- surfaces a *range of interconnected values, issues and opportunities* as issues can either negatively affect multiple values and opportunities can likewise positively enable a range of values, and values can impact one another.
- prompts new issues and opportunities as participants discuss the consequences of the issue and opportunity clusters.

As with the issues and opportunities where there are links between the values these were captured. Thus, each workshop generated a 'map' of interconnected issues and opportunities supporting a value *system* articulating not only the social and economic values as viewed by participants, but additionally the issues and opportunities substantiating them. The networks generated in each focus group ranged from around 60 statements to over 100 enabling participants to have a deeper and more systemic understanding of MMS associated values, issues and opportunities and capturing a rich idiosyncratic representation of a particular cohort's perceptions of MMS. In each workshop these 'systems' of goals/values reflected the shared (across all of the workshop participants) values as well as values identified by particular individuals (Bryson et al., 2016).
As a final activity, participants were asked for their views on the workshop process before being thanked for their participation. This feedback provided valuable input in terms of improvements to the design of the focus group workshops as well as insights into the facilitation experience, and benefits of the on-line method. Each participant received a workshop report comprising the material generated (a complete set of the mini reports can be found in Appendix 8).

Concluding the series of focus group workshops the data was integrated allowing for exploration and analysis across the entire body of material (see figure 10).

Figure 10: Summary of social value workshop method – showing the workshop process, the data elicited and its integration.



Note: the activities on the left represent the workshop process, providing categories of data for analysis, and subsequently enabling insights to be gained against each data set.

Analysing the data

Concluding the 11 workshops, analysis on the data sets was conducted. Analysis of causal maps (comprising subjective data) is well established (Eden and Ackermann, 1998; Bryson et al., 2004) for the management of qualitative data and encompasses a wide range of analyses. These include; examining the networks for those statements that are central to the structure, comprise feedback dynamics, emerge as significant triggers and reveal themselves to be well elaborated values. Leveraging the capabilities of the mapping analyses a number of activities were conducted including:

- Comparing the varying heterogeneity/homogeneity across cohort groups (values, opportunities, and issues) giving rise to a set of generic values/themes and dominant issues and opportunities (see Figure 10 right hand side).
- assessing the interactions (links) between values to construct a decision tree amenable to constructing a multi-criteria model and a value system map.
- exploring how dominant issues and opportunities impacted generic values.

Table 8 outlines the process.

Table 8: Summary of group social value analysis method and outputs.

Analysis	Data Used	Program(s) Used	Outputs (see results)
Issues & Opportunities	Issues and opportunities from 11 workshops	Microsoft PowerPoint Microsoft Excel Group Explorer	Generic issues and opportunities
Themes analysis	Workshop themes from 11 workshops	Microsoft Excel Microsoft Word	Meta-themes Meta-themes importance ratings
Values analysis	Workshop values from 11 workshops	Microsoft Excel Microsoft Word Microsoft PowerPoint Group Explorer	Meta-values Meta-values mapped onto literature framework Meta-values map Generic values Generic Values decision tree Generic values spider plot

Methods: Collation of WA MMS

The objective of this component of the project was to collate data from multiple sources to gain an understanding of the types and numbers of MMS located within Western Australia's marine environment.. We did a search of the primary literature using Google Scholar. We also directly approached, or sourced information from the websites of organisations whom we knew had been involved in the deployment of infrastructure and collection of data in Western Australia.

For artificial reefs this included Recfishwest, the Department of Primary Industries and Regional Development, SubCon and Ocean Grown Abalone.

Data on shipwrecks was downloaded from www.data.wa.gov.au while data on maritime facility locations including boat ramps, jetties, slipways, groynes, wharfs, and harbours was provided directly by the Department of Transport.

Data on O&G infrastructure was sourced from the National Offshore Petroleum Titles Administrator (NOPTA) and Geoscience Australia (https://nopims.dmp.wa.gov.au/Nopims/GISMap/Map).

For ease of access, we have summarised data into an Excel spreadsheet under various tabs (see links to the database below).

The spatial component of the database consists of GIS layers (points, lines, and polygons) in ESRI shapefile format. Sources of data were combined, most of them obtained through WFS (Web-feature-service) freely provided by institutes and government organisms (see table below). Layers were processed in QGis software, filtered and reprojected (when necessary) to GDA94 (EPSG:4283), and finally converted to ESRI shapefile format. Other datasets were obtained in CSV format using the latitude and longitude information provided. These datasets were adapted to be transformed into point layers, reprojected, and included in the database as shapefiles.

All layers were analysed together to avoid duplicated data, and had a column added ('SOURCE') to its attribute table stating the original source of the spatial data. When infrastructure objects were repeated, but in different formats (e.g.: As lines and then as polygons), both objects were kept in the database. Area and length calculations were done in projected coordinates: GDA_1994_Australia_Albers (EPSG:3577).

Table 9: Sources of spatial data.

Dataset	Source	Type	N objects
Petroleum wells	AIMS database	point	395
Petroleum wells	https://catalogue.data.wa.gov.au	point	2309
Recfish AR	other/various	point	9
National Onshore pipelines	AIMS database	lines	122
O&G platforms	AIMS database	point	59
O&G platforms	https://services.ga.gov.au/	point	38
Navigation aids	https://catalogue.data.wa.gov.au/	point	2684
Tide stations	https://catalogue.data.wa.gov.au/	point	47
Maritime facility locations	https://catalogue.data.wa.gov.au/	point	41
Coastal infrastructure DOT-polygon	https://catalogue.data.wa.gov.au/	polygon	7726
Coastal infrastructure DOT-points	https://catalogue.data.wa.gov.au/	point	5685
Artificial structures (from SmartLine)	http://www.ga.gov.au/	lines	303
Gas pipelines	https://services.ga.gov.au/	lines	689
Oil pipelines	https://services.ga.gov.au/	lines	73
Shipwrecks	https://catalogue.data.wa.gov.au/ + other	point	305

The spatial database is available through Cloudstore at https://cloudstor.aarnet.edu.au/plus/s/ZEJ7zkxaJwyNFid

A visualisation of the data is available at https://aimsdata.maps.arcgis.com/apps/webappviewer/index.html?id=e534ab2975f64ca68479cc291dcb3a9f

We are aware that this list will not be all-inclusive, but is meant to aid stakeholders to understand the extent and types of MMS in the marine environment. It is also a starting point if there is a need to scale the social and economic benefits and values of MMS to a broader Western Australian context. We reiterate that this does not include subsea telecommunication cable or aquaculture infrastructure.

Methods: Integration of components

The three components (social values – individual, social values – group and economic values) were integrated through a number of mechanisms. Firstly, the team met regularly to discuss emerging findings and how they triangulated, secondly representatives from the economic group and social value individual team attended the social group workshops to understand both the process and the data. Finally, at the end of the data collection stage several workshops with the research team were held. In the first workshop, the team collated the values that each component found in their data collection using the Group Support System that was used in the social value group workshops (to allow for breadth and to recognise the impacts of values upon one another). We then identified the most significant values by applying two criteria: (i) values that were identified by multiple components and/or (ii) values that substantially influenced other values. In this process, the links and their causal direction between the different values were also identified. Moreover, we discussed the definition of the values of each component and identified three value categories that encompasses the value definitions of all components: user values, community values and environmental values. We classified each value to one of these overarching value categories recognising that some of the values could relate to more than one category. Kumu software (https://kumu.io/) was used to illustrate the values and their interactions in a map. Finally, we reviewed the map in multiple iterations of the same process described above. The results of the integrated value map are described in the discussion section. We also reviewed the issues and opportunities surfaced by both social value groups to determine their similarities and allow for a more holistic appreciation.

Section 4: Results

Results: Systematic literature review

Social values

Despite strong advocacy for the inclusion of social values in marine planning for MMS (Shaw et al., 2018), academic and grey literature directly addressing this topic was limited. A total of 126 relevant publications were identified. Within these, our review identified 33 papers addressing an aspect of social value, categorised as: (i) social values associated with MMS (8 papers); (ii) stakeholder perceptions of MMS (23 papers); and (iii) stakeholder use and satisfaction with MMS (11 papers). Within the small number of papers (8) addressing social values, a range of MMS types were covered, including artificial reefs, natural reefs, sea walls, offshore wind turbines and O&G infrastructure. Furthermore, these articles encompassed data from a broad range of stakeholder groups (recreational and commercial fishers, divers, tourism sector representatives, environmental groups, and various government institutions) (refer to Table 8, p22, Literature review report, Appendix 2).

Due to the breadth of structures and stakeholder groups, trends in social values by stakeholder group or structure type could not be derived from the literature review. The literature, did however, indicate stakeholder values are likely contingent on MMS structure type. For example, recreational divers valued the diversity of species associated with artificial reefs (Ramos et al., 2006) whilst recreational fishers' values were affected by the presence or absence of commercial fishers on natural reefs (Barclay et al., 2017). Furthermore, stakeholder groups' values were influenced by less tangible factors than structure type, as demonstrated by Voyer and colleagues in their finding that the presence of a commercial fishing industry was positively associated with tourists' experience of a location (Voyer et al., 2017).

Comparatively, there were a relatively large number of academic and professional publications examining perceptions and perceived benefits of MMS from a variety of locations worldwide (23); however, the majority of these related to either artificial reefs or offshore wind turbines. These studies demonstrate that stakeholder groups can hold markedly different views on the environmental benefits of artificial reefs (e.g. (Ramos et al., 2007) whilst also highlighting the issues surrounding access rights to newly installed offshore infrastructure (Kruse et al., 2015).

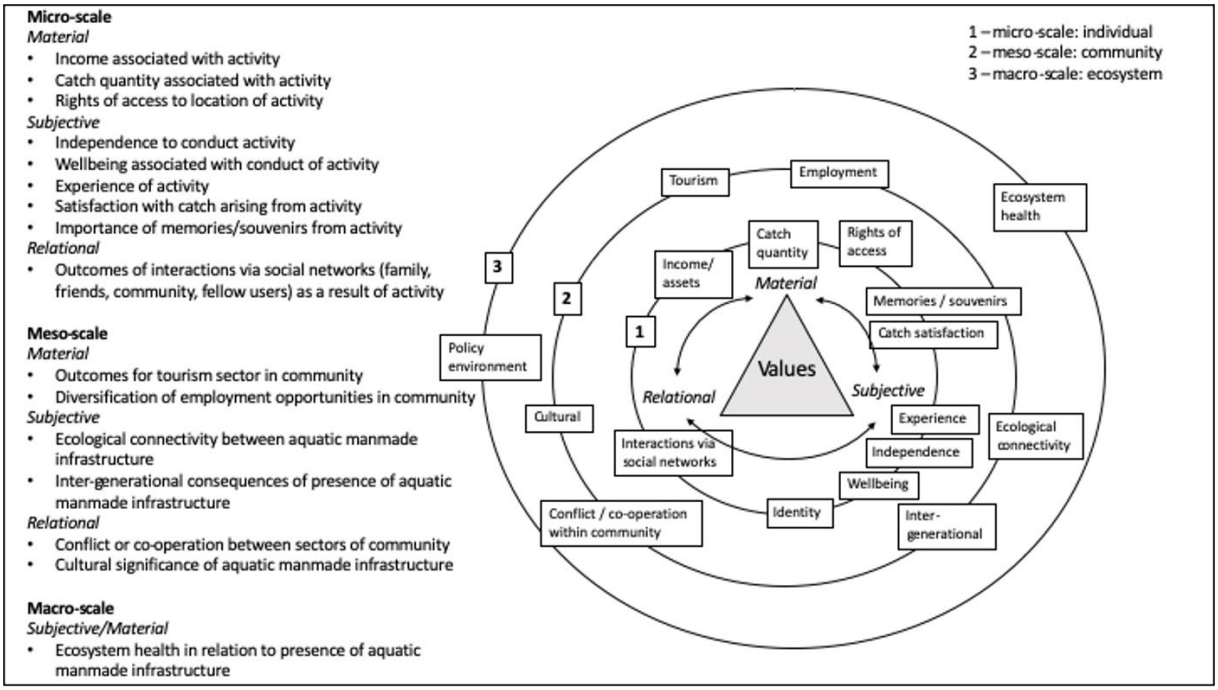
Papers exploring the use of, and satisfaction with MMS predominantly focussed on recreational divers' use of artificial reefs, and the characteristics of divers (e.g. dive experience) associated with site preferences (e.g. natural versus artificial reefs or habitat preferences; refer to Table 7, Literature review report, Appendix 2). Information ranged from examining the types of dive activities underway (Ditton et al., 2002a), to preferences for different forms of artificial reef (e.g. Shani et al., 2012) and marine environments (e.g. natural versus artificial; Belhassen et al., 2017) and habitat preferences (Kirkbride-Smith et al., 2013).

The output of the review was a limited understanding of the range of social values derived from MMS and how these differ within or between stakeholder groups and structure types. To address this outstanding gap in knowledge, themes from across the review were collated to develop a conceptual framework of the elements relating to social value of MMS. The themes included (i) multiple stakeholders (direct and indirect); (ii) values, which were distinguished by scale (e.g., personal values/global values) and theme (e.g. measurable/material values, intrinsic/subjective values, relational values); (iii) multiple structure types (e.g. artificial reefs, offshore wind farms); and (iv) the

enactment of values or activities that shape values (including use and behaviours, perceptions/attitudes).

The output was a framework that highlighted the importance of cross-scale and multiple themed values. It is closely aligned to the social well-being framework that has been advocated as an approach to integrate social, economic and environmental aspects in fisheries management (see for example (Weeratunge et al., 2014) and (Johnson et al., 2018)). As per the framework derived from the literature review, the social well-being framework presented in the broader fisheries literature considers values across scales (micro, meso and macro) and across themes (material, relational and subjective). Consequently, the established, peer-reviewed representation of social values, adopting the well-being lens as reported in (Weeratunge et al., 2014) was modified for a MMS context and established as the conceptual model supporting the ongoing research (Figure 11).

Figure 11: Conceptual model of the social values of MMS, following Weeratunge et al. (2014).



Economic values

The systematic literature research found 34 studies that quantified the economic value that MMS provides to stakeholders such as divers, recreational and commercial fisheries, the general public, and other user groups (see table in Appendix 2). Over the last decades, the number of publications on this topic has steadily increased. The most common structure type investigated are purpose built ARs (18 studies) and shipwrecks (15 studies). We also found six studies on offshore O&G platforms and one on offshore wind turbines. While the literature indicated economic values from MMS all over the world, half of these studies were conducted in the USA. Structures in other regions in the world were far less studied. All 34 articles quantified direct use values (19 extractive use values and 17 non-extractive use values), whereas non-use values were assessed by only two studies. None of the studies estimated indirect use values, even where the context of the studies was relevant for indirect use values (e.g., coastal protection).

Direct use values

Business Revenues

Papers focusing on use values of MMS found that they generate direct use values in terms of business revenues from extractive uses such as commercial fishing (Brock, 1994; Vivekanandan et al., 2006; Islam et al., 2014) and recreational fishing (Buchanan, 1973; Milon, 1989; Brandini, 2014; Morgan et al., 2018). For example, Buchanan (1973) estimated that an artificial reef in South Carolina, USA caused an increase of 10% in the gross economic contribution of marine recreational fishing in the region. In the Gulf of Mexico, a significant part of the commercial harvest of snappers originated from O&G platforms (Bull and Love, 2019). Moreover, Kolian et al. (2018) estimated that in the Gulf of Mexico, a sustainable harvest of aquarium fish could yield approximately USD 1.4 million per O&G platform per year (note that all values are reported in 2019 USD). They also pointed out that there is an unknown value in novel pharmaceutical and/or nutritional products that could be sourced from marine invertebrates that grow on O&G platforms. However, Islam et al. (2014) found that benefits from artificial reefs, including O&G structures- in Malaysia were unequally distributed among artisanal fishers and suggest that sustainable fisheries management within the artificial reef development should ensure economic benefits for the local fishing communities.

Literature also found MMS to provide business revenues through non-extractive uses such as scuba diving (Dowling and Nichol, 2001; Ditton et al., 2002b; Leeworthy et al., 2006). For example, (Dowling and Nichol, 2001) analysed the expenditures from dive tourists that visit the HMAS Swan shipwreck in Western Australia and estimated the annual economic impact to be USD 1.39 million. Johns et al. (2001) estimated that shipwrecks in Southeast Florida provided 26,800 jobs for the tourism industry and were generating USD 2.4 billion of revenues annually. (Hiett and Milon, 2002) found that recreational fishing and diving associated with O&G facilities in the Gulf of Mexico not only generated USD 324.6 million in annual economic revenues, but also provided employment for approximately 5,560 full time equivalents. Both fishing charter and dive tour operators considered the presence of O&G structures to be very important to their businesses.

Two articles compared economic values of commercial fishing opposed to recreational and/or tourism activities on shipwrecks (Brock, 1994; Crabbe and McClanahan, 2006). Both studies found that the revenues generated from recreation and tourism greatly exceeded those from commercial fishing.

Non-market direct use values

In addition to business revenues, MMS were found to provide economic benefits in terms of increased satisfaction (consumer surplus) to users. McGurrin and Fedler (1989) found e.g., that the increase in catchability and/or catch rate around O&G platforms in the USA improved satisfaction of recreational fishers which translated into fishers on O&G platforms being WTP more ($19.38 USD) than non-platform fishers ($10.00 USD).

Users also were found to value the fact that MMS can deviate user pressure from natural reefs. For example, the construction of a dive and snorkel trail in Dahab, Egypt was meant to prevent tourists from trampling on and therefore damaging natural reefs. (Hannak et al., 2011) used the Contingent Valuation approach and found that especially the less experienced snorkelers (who are more likely to damage reefs) were WTP for the snorkel trail and an educational training to protect natural reefs.

Moreover, literature indicated that the controlled position of artificial reefs can allow for safer conditions than on some natural sites. Christie and Colman (2009) assessed the economic value associated with safer swimming conditions and found that members of a community in Wales held significant values for a multipurpose reef which would provide such conditions. Likewise, Taiwan

residents were WTP about $13 USD per recreational fishing and diving trip for access to an artificial reef zone that provided safer conditions than surrounding areas (Chen et al., 2013).

Comparison of values for MMS and natural marine habitat

Nine studies compared economic values related to MMS with those from non-MMS sites. Out of these, six studies found higher economic values on MMS than on adjacent areas (Johns et al., 2001; Vivekanandan et al., 2006; Oh et al., 2008; Whitmarsh et al., 2008; Kasim et al., 2013; Smith et al., 2016). Kasim et al., (2013) found e.g., that the revenues of commercial fishers in India were over twice as high on artificial reefs compared to non-artificial reef areas. Johns et al., (2003) observed that recreational divers in South-East Florida were WTP over twice as much to protect natural reefs (USD 229.3 million/year) than to protect a shipwreck (USD 85.1 million/year). However, Huth et al., (2015) found that dive tourists in Florida had a higher WTP for a dive trip to a shipwreck (USD 368) than to natural reefs (USD 300) and Islam et al., (2014) found that the monthly fishing income from artisanal fishers on an artificial reef in Malaysia was lower than on adjacent natural reefs.

Non-use values

MMS have the ability to enhance marine habitat and therefore improve the biodiversity and/or abundance of marine life on and around them. Hence, people who value these natural benefits can have a WTP for maintaining artificial structures, even when they do not necessarily use them. We found two articles that measured non-use values of artificial reefs. Börger et al., (2015) used a DCE to estimate the WTP of residents in Ireland for an increase in biodiversity on an offshore wind farm off the coast of Ireland. They found that people were WTP GBP 7.25 and GBP 14.83 per person for an increase of ten and 30 species settling on the wind farm, respectively. Hicks et al. 2004 found a positive attitude towards oyster reef restoration programs in the USA and estimated that residents were WTP USD 86.68 per year to fund oyster reef programs although they did not necessarily use such reefs.

For full details on the results of the literature review, see “Socioeconomic values associated with man-made aquatic infrastructure academic literature review” in Appendix 2.

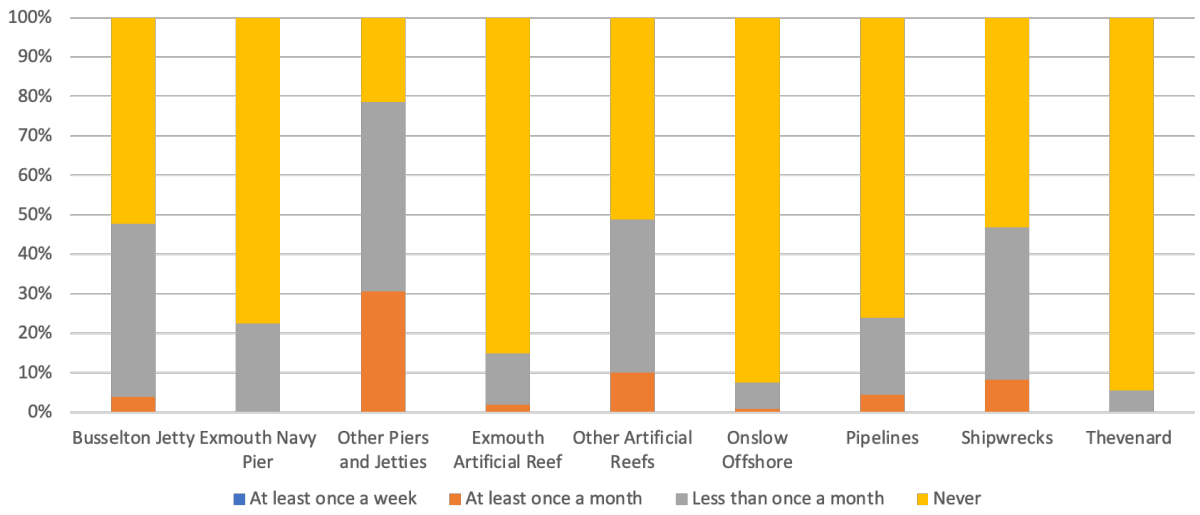
Results: Social values - Individual

In this section we present the results of the Social Values Individual component of the research. We discuss how often stakeholders are interacting with MMS by type, the values they derive from this interaction and their views on MMS in Western Australia. We also present the opportunities and limitations that stakeholders associate with MMS and explore how these views are consistent with or differ by stakeholder groups. We present the outcomes of a case study survey exploring the micro-values generated from Busselton Jetty. Detail on the characteristics of the survey respondents is presented in Appendix 3.

Use of MMS in Western Australia

The majority of the survey respondents self-classified as recreational fishers (64.2%) followed by divers (16.4%), 'other' (7.5%) (including for example local government, tourism, or research sectors), or a commercial fisher (4.9%). Piers and jetties were the primary MMS structure used by respondents in the last 12 months, followed by artificial reefs and shipwrecks (Figure 12). There was however, overall, low levels of use of MMS across the surveyed population, with the majority of the MMS structure types and sites being used less than once per month, or never in the last 12 months, by survey respondents.

Figure 12: Frequency of use of select MMS structures and types of MMS.



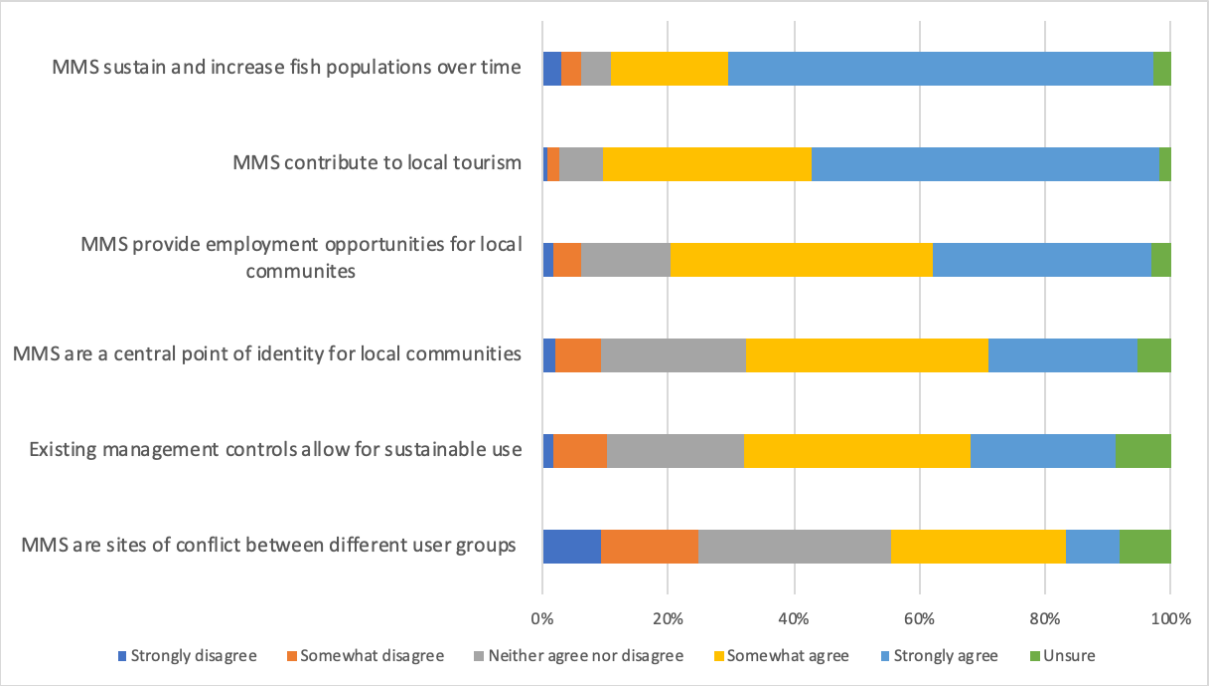
The dominant MMS type used differed across stakeholder groups, with jetties and piers the most frequently used MMS for recreational fishers, divers, and others. For commercial fishers' pipelines were the most frequently used MMS. Divers also more frequently visited shipwrecks compared to the other stakeholder groups.

The case study sites, comprising Busselton Jetty, Exmouth Navy Pier, Onslow Offshore Structures and Thevenard, were rarely used by survey respondents in the last 12 months.

Respondents' perceptions of MMS

Most of the survey respondents strongly agreed that MMS increase and sustain fish populations over time, while there was limited agreement with the statement that MMS are sites of conflict between different user groups (Figure 13).

Figure 13: Agreement with statements relating to MMS and its contribution to environment, society and economy.



Perceptions were, however, not consistent across the stakeholder groups. In particular, commercial fishers and those that did not classify as recreational fishers or divers (i.e., 'others') were less likely to agree that MMS sustain and increase fish populations over time, or that MMS contribute to local tourism in comparison to divers and recreational fishers (Table 10). In contrast, 'others' and commercial fishers more frequently agreed that 'existing management controls allow for sustainable use of MMS', than recreational fishers or divers.

We found that the self-assigned stakeholder group for each respondent, their age and the types of MMS used by the respondent in the last 12 months were all significant factors explaining differences in perceptions. For example, stakeholder group was the explanatory factor for differences in perceptions regarding the contribution of MMS to sustaining and increasing fish populations over time and the contribution of MMS to local tourism, with recreational fishers and divers more frequently expressing higher levels of agreement with these statements than 'others' and commercial fishers. Age was also a defining factor explaining variation in the perceived contribution of MMS to fish populations and tourism, with respondents under 55 years of age generally having lower levels of agreement with this statement. This group was also less likely to view MMS as a point of identity for local communities compared to respondents aged over 55 (see Table 10). The type of MMS structure used by the respondent was also associated with differences in perceptions. Specifically, respondents that only used jetties or piers in the last 12 months were more likely to agree that MMS contribute to local community identity than respondents that had not used MMS in the last 12 months. Further, respondents who had used all forms of MMS in the last 12 months were more likely to agree that MMS sustain and increase fish populations over time than other users.

Table 10: Perceptions of MMS: All respondents - ordinal regression outputs

Perception	Model Fitting Sig	Goodness of Fit	Significant relationships between variables
MMS increase and sustain fish populations over time	0.000	Pearson: 210.73 Sig: 0.986	Independent variable (Divers; Rec Fishers): significantly greater level of agreement with perception than base group (other respondents) Independent variable (Respondents using all MMS): significantly greater level of agreement with perception than base group (Respondents with no usage of MMS) Independent variable (Gen X; Gen Y): significantly lower level of agreement with perception than base group (respondents over 55 yrs old)
MMS contribute to local tourism	0.004	Pearson: 237.662 Sig: 0.813	Independent variable (Divers; Rec Fishers): significantly greater level of agreement with perception than base group (other respondents) Independent variable (Gen X): significantly higher level of agreement with perception than base group (respondents over 55 yrs old)
MMS contribute to local employment opportunities	0.120	Pearson: 248.301 Sig: 0.657	-
MMS are a point of local community identity	0.004	Pearson: 249.559 Sig:0.635	Independent variable (Respondents using jetties only): significantly greater level of agreement with perception than base group (Respondents with no usage of MMS) Independent variables (Gen X; Gen Y): significantly lower level of agreement with perception than base group (respondents over 55 yrs old)
MMS are managed sustainably	0.136	Pearson: 246.329 Sig: 0.411	-

MMS are sites of conflict	0.015	Pearson: 231.467 Sig: 0.738	Independent variable (Male respondents): significantly lower agreement than base group (Female respondents)

Note: This table identifies significant differences in prioritisation of perceptions between independent variables (eg experience level, age, gender) within all respondents against a base group. Thus, for example, dive respondents and fisher respondents who had used all types of MMS in the last 12 months were significantly more likely to agree than the base group (in this case, other respondents) that MMS increase and sustain fish populations over time. Where no significant differences were observed, cells are blank.

There were also differences in perceptions within stakeholder groups. However, the number of respondents classifying as a commercial fisher or 'Other' was not large enough to perform statistical analysis within group variation, and therefore this analysis was confined to respondents identifying as recreational fishers or divers.

The statements with the highest degree of within group variation for the **recreational fishing respondents** included:

- MMS are a point of identity for local communities.
- MMS are sustainably managed.
- MMS are sites of conflict.

Respondents with limited recreational fishing experience (i.e. those who self-identified as 'beginners') were less likely to agree that MMS are a point of local community identity than those with greater experience (i.e. those who self-identified as 'experts'). Despite variable responses to the statements 'MMS are sustainably managed' and 'MMS are sites of potential conflict', this variation was not explained by respondent age, experience, fishing type, MMS type used, gender or the importance assigned to recreational fishing as an outdoor activity (Table 11).). Finally, despite broad agreement with the statement that MMS increase and sustain fish populations over time (which was strongly agreed by a majority of recreational fishing respondents), users of all types of MMS were more likely to agree with this statement than non-users.

Table 11: Perceptions of MMS: Recreational fishing respondents - ordinal regression outputs

Perception	Model Fitting Sig	Goodness of Fit	Significant relationships between variables
MMS increase and sustain fish populations over time	0.181	Pearson: 518.561 Sig: 0.676	Independent variable (Users of all MMS in the last 12 months): greater level of agreement with perception than base group (Users of no MMS in the last 12 months)
MMS contribute to local tourism	0.322	Pearson: 551.308 Sig: 0.293	-
MMS contribute to local employment opportunities	0.227	Pearson: 589.94 Sig: 0.028	-
MMS are a point of local community identity	0.024	Pearson: 505.567 Sig:0.596	Independent variable (Experience level 'beginner'): significantly lower level of agreement with perception than base group (Experience level 'expert')
MMS are managed sustainably	0.224	Pearson: 587.92 Sig: 0.013	-
MMS are sites of conflict	0.880	Pearson: 515.616 Sig: 0.619	-

Note: This table identifies significant differences in prioritisation of perceptions between independent variables (eg experience level, age, gender) within recreational fishing respondents against a base group. Thus, for example, recreational fishers who had used all types of MMS in the last 12 months were significantly more likely to agree than the base group (in this case, recreational fishers who had not used MMS in the last 12 months) that MMS increase and sustain fish populations over time. Where no significant differences were observed, cells are blank.

Similarly (see Table 12), there was some within group variation in perceptions for **dive respondents**, with jetty users less likely to agree that MMS contribute to local tourism and employment opportunities than non-users of MMS; and more likely to agree that MMS are sites of conflict. Those that more frequently dive were also more likely to agree that MMS are sites of conflict than those that rarely dive. Finally, divers with less experience were more likely to agree that MMS are a point of identity for local communities, and less likely to agree that MMS are sites of conflict.

Thus, the perceptions that MMS are sites of conflict resonated most strongly with experienced and frequent divers that use jetties.

The results indicate that while there appears to be strong agreement that MMS benefit marine ecosystems, perceptions are not consistent within or across stakeholder groups. This highlights the importance of understanding perceptions and drivers to inform communication efforts.

Table 12: Perceptions of MMS: Dive respondents - ordinal regression outputs

Perception	Model Fitting Sig	Goodness of Fit	Significant relationships between variables
MMS increase and sustain fish populations over time	0.503	Pearson: 121.612 Sig: 1.000	-
MMS contribute to local tourism	0.361	Pearson: 117-494 Sig: 0.140	Independent variable (Users of jetties only): lower level of agreement with perception than base group (Users of no MMS in the last 12 months)
MMS contribute to local employment opportunities	0.754	Pearson: 148.29 Sig: 0.698	Independent variable (Users of jetties only): lower level of agreement with perception than base group (Users of no MMS in the last 12 months)
MMS are a point of local community identity	0.154	Pearson: 213.098 Sig:0.618	Independent variable (Experience level 'beginner'): significantly higher level of agreement with perception than base group (Experience level 'expert')
MMS are managed sustainably	0.669	Pearson: 199.326 Sig: 0.500	-
MMS are sites of conflict	0.022	Pearson: 224.801 Sig: 0.202 Threshold 1 (1.678) – 4 (8.894)	Independent variables (Users of jetties only; users of combination of MMS; users of all MMS): significantly higher level of agreement with perception than base group (Users of no MMS) Independent variable (Experience level 'beginner'): significantly lower level of agreement with perception than base group (Experience level 'expert') Independent variable (Gen Y): significantly higher level of agreement with perception than base group (respondents over 55 yrs old)

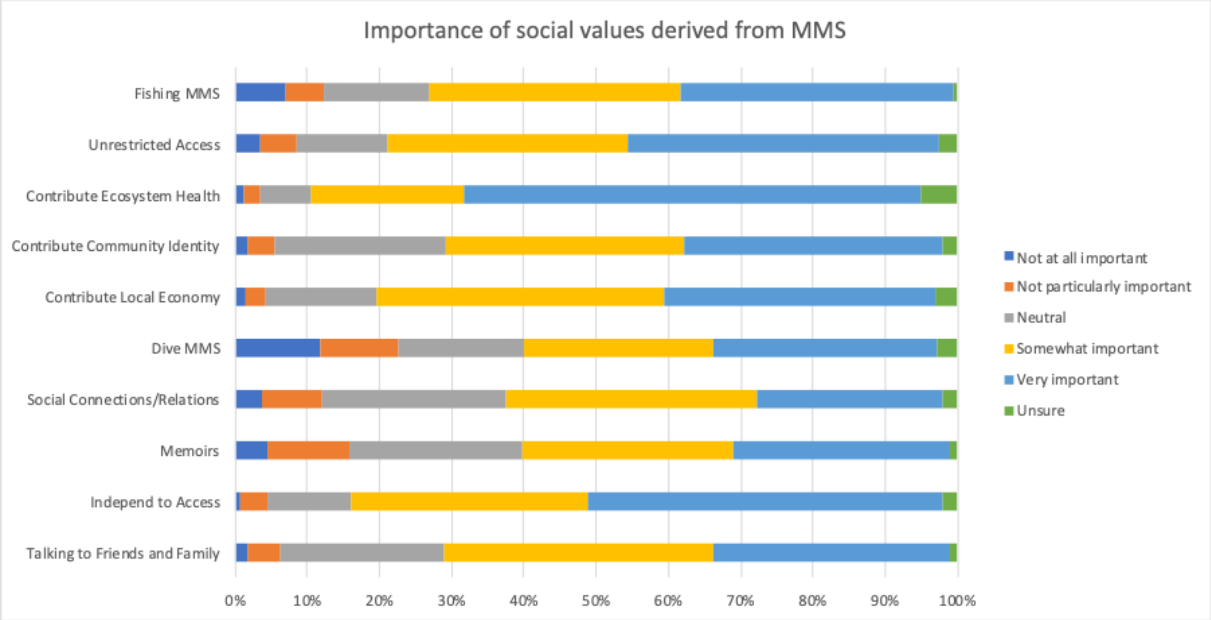
Note: This table identifies significant differences in prioritisation of perceptions between independent variables (eg experience level, age, gender) within diver respondents against a base group. Thus, for example, divers who used jetties only were significantly less likely to agree than the base group (in this case, divers who had not used

MMS in the last 12 months) that MMS contribute to local employment possibilities. Where no significant differences were observed, cells are blank.

Social values derived from MMS

The most important **value** derived from MMS for the surveyed respondents was the contribution of MMS to ecosystem health; followed by (i) independence to choose when or how they access MMS, and (ii) unrestricted access to MMS (Figure 14).

Figure 14: The importance of social values derived from MMS.



The prioritisation of values was, however, not consistent across the stakeholder groups. There were significant differences in the priorities assigned to the following value statements:

- The importance of fishing MMS
- The importance of diving MMS
- The importance of unrestricted access to MMS,
- The importance of memoirs and souvenirs collected from activities undertaken at MMS (question asked of fishers and divers only)
- The importance of the contribution of MMS to ecosystem health
- The importance of the contribution of MMS to local economy and
- The importance of the contribution of MMS to local community identity

Significant differences in the importance assigned to fishing and diving is self-explanatory, with recreational fishers assigning higher priority to this value than other stakeholder groups, and divers assigning higher priority to the importance of diving compared to other stakeholder groups. Therefore, further analysis of the factors influencing differences in perceived value (and whether stakeholder group was the dominant variable shaping value differences) was focussed on the remaining five value statements.

We found that the factor influencing value prioritisation differed depending on the value statement (Table 13). In some cases, stakeholder group was the dominant factor, whilst in others it was the use of different types of MMS. For example, and as would be expected, there was a clear distinction in

the importance of values such as, 'fishing MMS', 'diving MMS', 'memories from visiting/using MMS', 'unrestricted access to MMS' and social aspects of MMS use (e.g. talking to friends and family about experiences, social connections made), for active MMS users compared to those that had not used MMS in the last 12 months.

Table 13: Values derived from MMS: All respondents - ordinal regression outputs

Value	Model Sig	Goodness of Fit	Significant relationships between variables
Fishing MMS	0.000	Pearson: 234.886 Sig: 0.885	Independent variable (Rec Fishers): significantly greater level of agreement with perception than base group (other respondents) Independent variables (Users of jetties only; users of combination of MMS; users of all MMS): significantly greater level of agreement with perception than base group (Respondents with no usage of MMS)
Diving MMS [fish, dive, neither only]	0.000	Pearson: 211.635 Sig: 0.687	Independent variable (Rec Fishers): significantly greater level of agreement with perception than base group (other respondents) Independent variables (Users of jetties only; users of combination of MMS; users of all MMS): significantly greater level of agreement with perception than base group (Respondents with no usage of MMS) Independent variable (Gen Y): significantly lower level of agreement with perception than base group (respondents over 55 yrs old)
Memories [only rec fish and divers]	0.003	Pearson: 196.34 Sig: 0.192	Independent variable (Divers): significantly greater level of agreement with perception than base group (rec fishers) Independent variables (Users of jetties only; users of combination of MMS; users of all MMS): significantly greater level of agreement with perception than base group (Respondents with no usage of MMS)

Unrestricted access	0.000	Pearson: 245.06 Sig: 0.576	Independent variables (Divers; Rec Fishers): significantly greater level of agreement with perception than base group (other respondents) Independent variable (Respondents using all MMS): significantly greater level of agreement with perception than base group (Respondents with no usage of MMS) Independent variable (Gen X; Gen Y): significantly lower level of agreement with perception than base group (respondents over 55 yrs old)
Independence to choose when to access [only rec fish and divers]	0.252	Pearson: 156.42 Sig: 0.747	Independent variable (Gen Y): significantly lower level of agreement with perception than base group (respondents over 55 yrs old)
Talking to friends and family [only rec fish and divers]	0.180	Pearson: 215.24 Sig: 0.037	Independent variable (Respondents using all MMS): significantly greater level of agreement with perception than base group (Respondents with no usage of MMS)
Social connection made [fish, dive, neither only]	0.066	Pearson: 220.933 Sig:0.527	Independent variable (Respondents using all MMS): significantly greater level of agreement with perception than base group (Respondents with no usage of MMS)
MMS contribution to ecosystem health	0.079	Pearson: 230.56 Sig: 0.920	-
MMS contribution to local economy	0.211	Pearson: 651.429 Sig: 0.000	Independent variable (Rec Fishers): significantly greater level of agreement with perception than base group (other respondents)
MMS contribution to community identity	0.301	Pearson: 242.99 Sig: 0.742	-

Note: This table identifies significant differences in prioritisation of values between independent variables (eg experience level, age, gender) within all respondents against a base group. Thus, for example, recreational fisher respondents were significantly more likely to value the experience of fishing MMS than the base group (in this case, other respondents). Where no significant differences were observed, cells are blank.

We also found that divers placed greater importance on the memories and souvenirs obtained from MMS compared to the 'other' group; and recreational fishers assigned greater importance to the contribution of MMS to the local economy, compared to 'others'. Furthermore, both divers and recreational fishers valued unrestricted access to MMS more highly than 'others'. Unrestricted access

was also more highly valued by baby boomers than Generation Y respondents (across stakeholder groups).

Finally, despite significant differences in the value assigned to the contribution of MMS to ecosystem health, and to the role of MMS in contributing to local community identity, the difference was not explained by respondents age, gender, MMS use or stakeholder group. Perceptions and values are a function of a range of often immeasurable attributes including, for example, past experiences, worldviews, and political orientation (Chuang et al., 2020). If the variation in these values is an important consideration for MMS managers, further research would be required to identify core drivers.

Values expressed by the **recreational fishing** respondents varied based on the structures frequented, level of recreational fishing experience, and the importance assigned to recreational fishing as an outdoor activity (Table 14). For example, diving MMS was more highly valued by active users of MMS, and less valued by those that believed recreational fishing was the most important outdoor activity they undertook. Similarly, the value assigned to the memories derived from activities undertaken at MMS was higher for active users of MMS compared to non-users, but less valued by recreational fishers with 'advanced' experience compared to recreational fishing 'experts.'

The importance of fishing MMS increased with the level of experience of the survey respondent. The value assigned to unregulated access was also higher for: (i) male rather than female recreational fishers; (ii) respondents that believe recreational fishing is the most important outdoor activity they conduct, compared to those that view recreational fishing as just one of many outdoor activities; and (iii) self-assigned 'expert' recreational fishers more so than 'advanced' or 'intermediate' fishers.

For **divers**, the importance of the value statements was a function of how often they go diving. Respondents who dive once a week, or at least once a month, assigning greater importance to the social connections made and the memories obtained from diving MMS and less importance to the contribution of MMS to local economies and to the role of MMS in contributing to ecosystem health (Table 15). Differences in value prioritisation were also a function of divers' age, where talking to friends and family about diving experiences was less important to Gen Y and Gen X dive respondents than to Baby Boomers. Memories and unrestricted access were less important to Gen Y respondents than Baby Boomers.

In contrast to the recreational fishers, level of diving experience was rarely an influencing factor shaping the prioritisation of values for dive respondents. The type of MMS used was also rarely an influencing factor – only in relation to importance of fishing and diving MMS, where we found those that used all forms of MMS assigned greater importance to this value than those that do not use MMS.

Table 14: Values derived from MMS: Recreational fishing respondents - ordinal regression outputs

Value	Model Sig	Goodness of Fit	Significant relationships between variables
Fishing MMS	0.001	Pearson: 598.27 Sig: 0.036	Independent variables (Experience level 'beginner', 'intermediate' and 'advanced'): significantly lower level of agreement with value than base group (Experience level 'expert')
Unrestricted access to MMS	0.016	Pearson: 508.18 Sig: 0.745	Independent variable (respondents citing fishing as most important outdoor recreational activity): significantly higher level of agreement with value than base group (respondents citing fishing as one of many outdoor recreational activities) Independent variables (Experience level 'intermediate' and 'advanced'): significantly lower level of agreement with value than base group (Experience level 'expert') Independent variable (male): significantly higher level of agreement with value than base group (female)
Diving MMS	0.017	Pearson: 550.808 Sig: 0.298	Independent variables (Users of combination of MMS; users of all MMS): significantly greater level of agreement with value than base group (Respondents with no usage of MMS) Independent variable (respondents citing fishing as most important outdoor recreational activity): significantly lower level of agreement with value than base group (respondents citing fishing as one of many outdoor recreational activities) Independent variable (Gen Y): significantly higher level of agreement with value than base group (respondents over 55 yrs old)
Social Connections	0.033	Pearson: 517.62 Sig: 0.642	-
Independence to choose access	0.274	498.72 0.886	Independent variables (Experience level 'intermediate' and 'advanced'): significantly

			lower level of agreement with value than base group (Experience level 'expert')
Memories/souvenirs	0.140	Pearson: 556.39 Sig: 0.283	Independent variable (Users of all MMS): significantly greater level of agreement with value than base group (Respondents with no usage of MMS) Independent variable (Experience level 'advanced'): significantly lower level of agreement with value than base group (Experience level 'expert')

Note: This table identifies significant differences in prioritisation of values between independent variables (eg experience level, age, gender) within recreational fishing respondents against a base group. Thus, for example, recreational fisher respondents with experience levels 'beginner', 'intermediate' and 'advanced' were significantly less likely to value the experience of fishing MMS than the base group (in this case, recreational fisher respondents with experience level 'expert'). Where no significant differences were observed, cells are blank.

Table 15: Values derived from MMS: Dive respondents - ordinal regression outputs

Value	Model Fitting Sig	Goodness of Fit	Significant relationships between variables
Fishing MMS	0.400	Pearson: 212.112 Sig: 0.562	Independent variable (Users of all MMS): significantly greater level of agreement with value than base group (Respondents with no usage of MMS)
Unrestricted access to MMS	0.000	Pearson: 203.302 Sig: 0.501	Independent variable (respondents who dive at least once a week): significantly greater level of agreement with value than base group (respondents who dive around once per year) Independent variable (Gen Y): significantly lower level of agreement with value than base group (respondents over 55 yrs old)
MMS contribution to ecosystem Health	0.065	70.876 0.964	Independent variables (respondents who dive at least once a week; respondents who dive at least once a month): significantly lower level of agreement with value than base group (respondents who dive around once per year)
MMS contribution to community Identity	0.568	184.033 0.883	-
MMS contribution to local Economy	0.643	185.990 0.021	Independent variables (respondents who dive at least once a week; respondents who dive at least once a month): significantly

			lower level of agreement with value than base group (respondents who dive around once per year)
Diving MMS	0.069	Pearson: 179.698 Sig: 0.114	
Social Connections	0.001	Pearson: 210.643 Sig: 0.513	Independent variable (Male respondents): significantly lower level of agreement with value than base group (Female respondents) Independent variables (respondents who dive at least once a week; respondents who dive at least once a month): significantly higher level of agreement with value than base group (respondents who dive around once per year)
Independence to choose access	0.067	231.492 0.091	Independent variable (respondents who dive at least once a week): significantly higher level of agreement with value than base group (respondents who dive around once per year)
Talking to friends and family	0.024	229.149 0.257	Independent variables (Gen X; Gen Y): significantly lower level of agreement with value than base group (respondents over 55 yrs old)
Memories/souvenirs	0.047	Pearson: 187.815 Sig: 0.917	Independent variables (respondents who dive at least once a week; respondents who dive at least once a month; respondents who dive around once every three months): significantly higher level of agreement with value than base group (respondents who dive around once per year) Independent variable (respondents citing diving as most important outdoor recreational activity): significantly higher level of agreement with value than base group (respondents citing diving as one of many outdoor recreational activities)

Note: This table identifies significant differences in prioritisation of values between independent variables (eg experience level, age, gender) within diver respondents against a base group. Thus, for example, diver respondents using all types of MMS were significantly more likely to value the experience of fishing MMS than the base group (in this case, diver respondents with no usage of MMS). Where no significant differences were observed, cells are blank.

Issues and opportunities associated with MMS

In addition to the quantitative questions exploring respondents' perceptions of MMS, survey respondents also had the opportunity to freely describe their views on the **benefits and/or limitations** of MMS from a social, economic, and environmental perspective. A total of 414 respondents, representing 80% of the total sample, identified benefits of MMS, with 399 respondents (77% of the total sample), identifying limitations. Around 80% of recreational fishing, diving and commercial fishing respondents gave open-ended responses, with a lower proportion of responses (58%) from those who did not fall into either of these user categories (hereafter termed 'Other'). Given the dominance of recreational fishers in the total sample (70%), their statements on benefits and limitations will inevitably colour the analysis. However, efforts were made to identify instances where other user groups' responses were characteristic of that group.

With regards to the benefits identified in association with MMS, almost half (45%) of all open-ended responses identified environmental benefits, followed by social (35%) and economic (19%). Very few (<1%) of respondents to this section of the survey failed to identify any benefits. With respect to environmental benefits, increased fish abundance or marine habitat was the most frequently identified, accounting for 22% of all environmental benefits cited, followed by the contribution of MMS to environmental sustainability (18%) and the creation of 'new' habitats in otherwise barren areas (15%).

Considering responses falling into the category of social benefits, the effect of MMS in promoting participation in marine activities, predominantly with reference to recreational fishing, accounted for 51% of responses, followed by accessibility to MMS structures (19%). Three sub-themes were identified with reference to participation, comprising more opportunities to enjoy recreational fishing arising from the increased number of fish in and around MMS; the opportunity for increased social interaction through increased participation; and the effect of MMS in enabling more people to participate in the activity. Sub-themes in the 'accessibility' category of responses included ease of access, equity of access with reference to aged or disabled users and personal safety.

Those respondents who identified economic benefits alluded to these occurring at both local and regional scales. Local economic benefits referenced the supply chain, specifically tackle and bait shops, whilst others mentioned broader benefits associated with increased tourism in general.

Analysis of the benefits identified by each stakeholder group was undertaken to identify any nuances within the respondent sample. The environmental and social benefits noted above were principally associated with recreational fishers, along with the mental health benefits of participation in fishing. Often these were couched in individual terms, i.e., the benefits to the individual of more opportunities to undertake recreational fishing, rather than community or regional benefits. However, it was apparent that divers were more likely to refer to environmental benefits in terms of MMS attracting greater biodiversity, rather than the benefits associated with 'using' biodiversity which were associated with recreational fishers. Respondents in the diver and 'Other' group were more disposed to mention the importance of raising awareness of the marine environment and the enjoyment of nature. These respondents were also more likely to identify tourism-related benefits than either commercial or recreational fishers.

A similar ranking to benefits was observed when analysing limitations identified by respondents in the open-ended section of the survey, 48% of which were categorised as environmental, 21% social and 7% economic. However, 38% of those who responded to the open-ended section of the survey identified no limitations, far greater than the <1% who failed to identify any benefits. However, these opinions were often predicated on the assumption that management arrangements were able to address any negative social or environmental impacts occurring in relation to the presence of MMS.

These included pollution or damage, including littering, pollution associated with MMS structural breakdown or environmental damage arising from poor construction, which were identified by 42% of respondents in the 'environmental' category. Over exploitation of the resource and disturbance to the natural environment were identified by 33% and 22% of respondents in the environmental category, respectively.

In terms of social limitations, a theme of overcrowding accounted for 37% of responses, followed by antisocial behaviour (30%). Overcrowding was commonly described with reference to environmental limitations including pressure on the natural resource. Antisocial behaviour referred to use of the structure for alcohol consumption and/or criminal activities alongside non-compliance with management regulations and disrespect for the natural environment. Within the small number of respondents who identified economic limitations, the dominant issue was the cost of constructing MMS, which accounted for 57% of responses.

There were few instances where an alignment of limitations could be identified with specific user groups, with all groups expressing a similar range of concerns. Divers were more likely to identify disrespect for the natural environment as a social concern, whilst environmental limitations associated with MMS causing a disturbance to the natural environment were raised by a small minority in the 'Other' group.

Busselton Jetty

As noted in the methods section, the aim of the Busselton Jetty survey was to obtain site-specific information on values and perceptions, as well as use levels for a case site. The number of responses (sample size) varied across user groups (recreational fisher n= 50, other n= 35, and diver n= 17) and did not allow between or within group analysis of variance in responses.

Use of Busselton Jetty

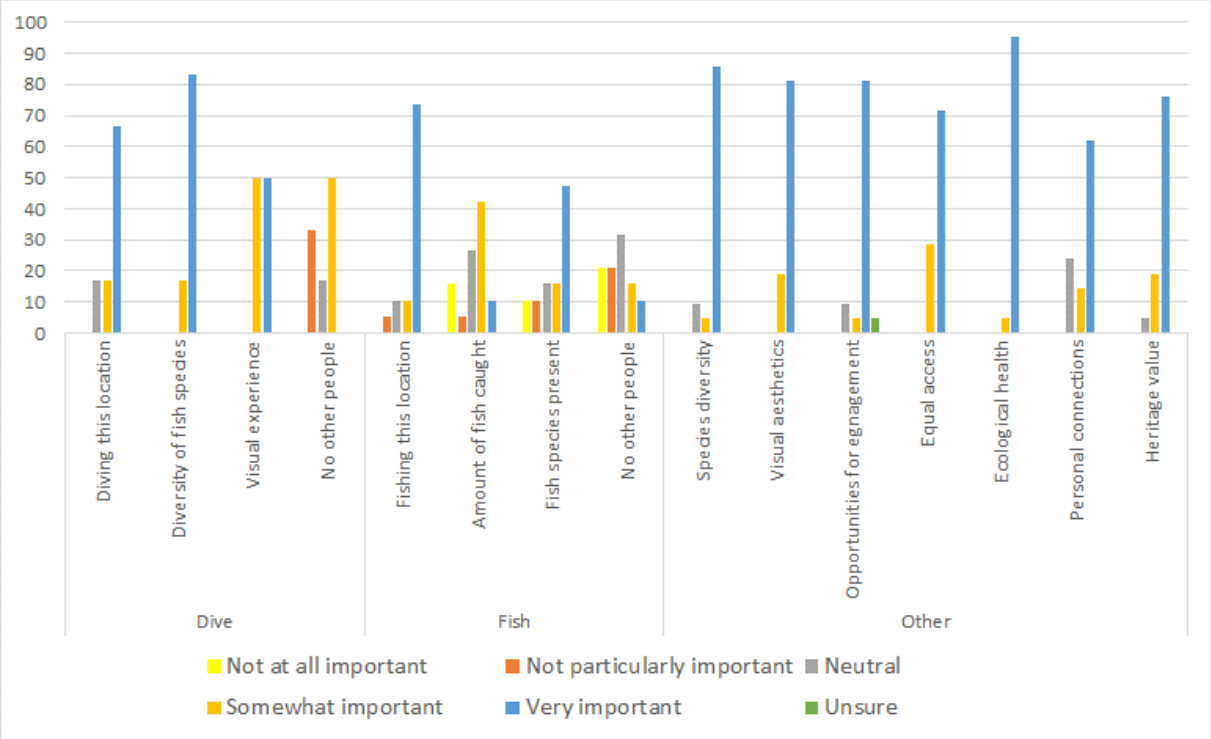
Of all case sites and categories of MMS, Busselton Jetty was the most frequently used MMS by respondents, whether divers, recreational fishers or others. Dive respondents used multiple types of MMS, with respondents from this group using jetties (in addition to Busselton Jetty), artificial reefs and shipwrecks at least once a month. The recreational fishing and other respondents' use of MMS was largely confined to piers and jetties. It should be noted that the smaller sample size of the diving group may contribute to the higher variability in proportionate use of MMS structure types. In accordance with the results of the State-wide survey, piers and jetties were the most frequently used MMS of all Busselton respondents. The case study sites, outside of Busselton Jetty, were again rarely used by respondents.

Micro-values derived from Busselton Jetty

Questions relating to the values users derive from Busselton Jetty (micro-values) sought to uncover values related to the respondent's core activity (e.g. diving or recreational fishing). The 'other' group included a broad range of users and use types, and therefore a greater number of possible micro-values were explored for this group (Figure 15).

For recreational fishers, the activity of fishing itself is of highest value, while the output derived from fishing (e.g., a diverse target species, and number of fish caught) is of less importance. For divers, the diversity of fish species present is of high importance, as too is the ability to undertake the activity at Busselton Jetty. 'Other' respondents rated almost all of the values as of high importance, although ecological health was the value that most frequently received the 'very important' rating (Figure 15).

Figure 15: Importance of micro-values derived from Busselton Jetty for each stakeholder group.



Note: values indicate the proportion (%) of respondents within each user group that assigned each level of value to each value statement.

Perceptions of MMS, Busselton respondents

Respondents recognised the role Busselton Jetty plays in contributing to tourism in the region, with over 70% strongly agreeing that 'MMS contributes to local tourism' - a higher proportion than for the State-wide survey. Approximately half of the respondents strongly agreed that MMS: increase fish populations; provide local employment opportunities; and are a point of identity for local communities. While there was least agreement that MMS are managed sustainably and are sites of conflict. Divers were more likely to strongly agree that MMS are sites of conflict than recreational fishers or 'others'.

There were different perspectives across the user groups on whether MMS are sustainably managed. Recreational fishers strongly agreed with this statement, while divers were most likely to 'somewhat agree' and 'others' more likely to 'somewhat disagree'. The differences in perceptions between the recreational fishing and dive respondents compared to other respondents were also apparent in relation to views on the role of MMS being a point of identity for local communities and the role of MMS in increasing fish populations. Others were more likely to strongly agree with the former and less likely to strongly agree with the latter compared to recreational fishing or dive respondents.

In short, stakeholder groups held divergent perceptions on MMS as sites of conflict, their sustainable management, their ability to provide a point of identity to local communities and their contribution to increasing fish populations. The factors influencing perceptions could not be statistically explored due to the small number of respondents in each user group.

Summary social values - Individual

The survey respondents did not frequently use offshore MMS, with jetties and piers accounting for the majority of respondents' use of MMS. Despite this, we identified that MMS contribute to multiple values, across the categories of material, relational and subjective, for both direct and indirect users. All user groups prioritised the contribution of MMS to ecosystem health above other potential benefits arising from MMS. However, respondents' perceptions that MMS actually contributed to ecosystem health varied, with recreational fishers and divers more likely to strongly agree that MMS sustain and increase fish populations over time than commercial fishers and 'Other' respondents.

The priority assigned to different values that come from direct and indirect interaction with MMS was not consistent across stakeholder groups, or within stakeholder groups. Nor was there consistency in the factors that influence value prioritisation – demonstrating diversity in both values and their influencing factors.
There was limited variation in perceptions and values within and between the recreational fishing and diving groups; however, where it existed, level of experience and age were the key factors influencing the prioritisation of values for recreational fishers, while for divers the core influencing factors were age and frequency of diving.

There was significant variation in perceptions and values within and between the commercial fishing and other groups, although the sample sizes constrained the ability to explore what factors shaped differences in values and perceptions. The commercial fishing group covered a range of commercial fishing types including some that use MMS and others whose interaction with MMS is limited. The Other group incorporates a range of different users, from tourism operators to researchers, and therefore their interaction with and relationship with MMS is widely different. The different engagement with MMS likely drives variation in the values derived.

Recreational fishers and divers had more positive perceptions of MMS than commercial fishers or other respondents. In particular, they were more likely to strongly agree that: (i) MMS sustain and increase fish populations over time; (ii) MMS contribute to local tourism; (iii) existing management controls allow for sustainable use; and (iv) MMS providing employment opportunities for local communities.

When averaged across stakeholder groups, all MMS values were considered important, by each stakeholder group (Figure 17). Key differences between user groups included the importance of unregulated access (i.e., open access to all) to the recreational fishers and divers versus commercial fishers and 'others'; and the high importance of MMS to the dive respondents. Similarly, perceptions of MMS were generally positive (Figure 17). Recreational fishers and divers agreed that MMS increase fish populations and contribute to local tourism and employment opportunities. There was less agreement that MMS are sites of conflict between user groups. Others and commercial fishers had more neutral perceptions than the former groups, with contribution of MMS to local tourism and employment opportunities receiving the highest average ratings of agreement for these groups. The only disagreement came from commercial fishing respondents with respect to the contribution of MMS to their target species.

To further explore the similarities and differences in values and perceptions within and between stakeholder groups we mapped the relative priority assigned to values and perceptions onto the social well-being framework. Note that for each map, the values and perceptions for the respondent

group could have been generally more or less positive than other groups. However, we explore the ***relative*** priority or agreement within each group and find (see Table 16 and Figures 3 - 6):

- Micro scale values are prioritised by recreational fishers and divers, and less so by commercial fishers and others; however, the later users assign importance to meso and macro scale values. *Key message: Even though micro (individual/personal) values are less prioritised by those that less frequently directly engage with MMS, this does not preclude the latter from valuing the broader scale benefits that MMS provide*.
- For the 'Other' group, relational values (management and research) were the highest relative priority of the group, along with ecosystem health. This is in contrast to recreational fishers and commercial fishers, where the relational values were relatively less important (excluding for unregulated access for recreational fishers) than material and subjective values. For divers, subjective values were the highest priority relative to other values. *Key message: The manner in which user groups interact with MMS, particularly with regards to extractive and non-extractive use, determines the relative prioritisation of subjective, material and relational values.*
- Across groups, there was most within group agreement with the statement that MMS contribute to local economies, via for example, tourism. *Key message: The material benefits of MMS arising from tourism is an attribute that receives the greatest recognition within and across all user groups.*

*Table 16: Summary of the **relative** importance of, and agreement with, statements of value and perceptions of MMS in Western Australia, per Stakeholder Group.*

Stakeholder Group	Scale	Value	Perception
Recreational fishing	Micro, meso and macro scale values of high importance (particularly ecosystem health and access).	Micro-scale relational values were a lower priority than micro-scale subjective values. At the meso scale, the relational value of unregulated access was a priority value, while at the macro scale, subjective/material value of ecosystem health was of significant importance.	Highest levels of agreement with statements relating to material and subjective benefits delivered by MMS Majority of perceptions are positive, although there is limited agreement that MMS are as sites of conflict.
Diving	Micro and macro scale values of highest relative importance (particularly ecosystem health, for select sites and WA more broadly).	Subjective values receive highest priority, including contribution to ecosystem health, diversity of species, and the activity of diving itself, followed by material value of local tourism contribution to the local economy.	Highest levels of agreement with statements relating to material and subjective benefits of MMS. Least agreement with relational statements. For example, agreement that MMS contribute to local fish populations and tourism, less agreement that they are managed sustainably or sites of conflict.
Other	Micro scale values are less important than meso and macro scale values. Site-specific values receive similar prioritisation to values at State level.	The high priority assigned to ecosystem health increases the relative prioritisation of subjective values. However, beyond ecosystem health, relational/material values including educational and research opportunities and the policy environment were important.	Most agreement with statements relating to the material benefits of MMS (tourism and local employment), less agreement with statements on sustainable management, or social or environmental benefits of MMS.
Commercial fishing	Most highly prioritised values are meso or macro-scale, rather than micro-scale.	Material and subjective values more important than relational.	Most agreement with statements relating to the material benefits of MMS, least agreement that MMS contribute to target species or that they divert pressure from natural sites.

Note: micro, meso and macro scales are defined in Weeratunge et al (2014).

Figure 16: Average importance of values derived from MMS in Western Australia, per user group.

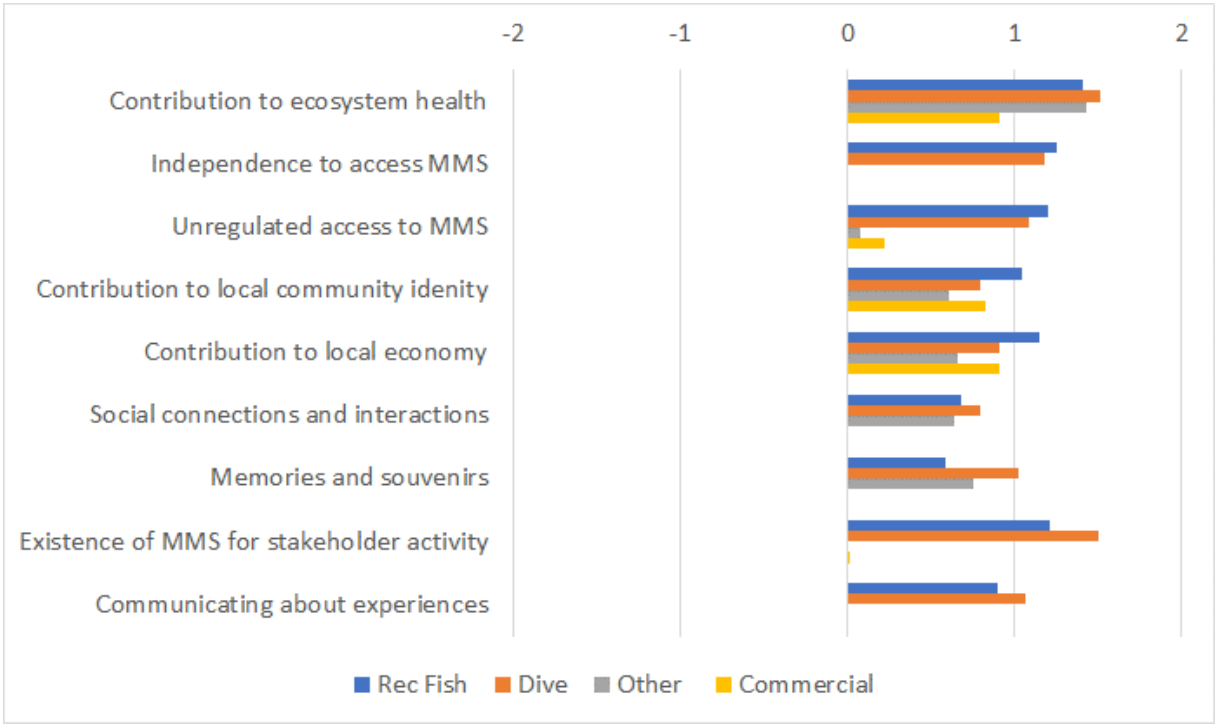


Figure 17: Average level of agreement to statements regarding MMS in Western Australia, per user group.

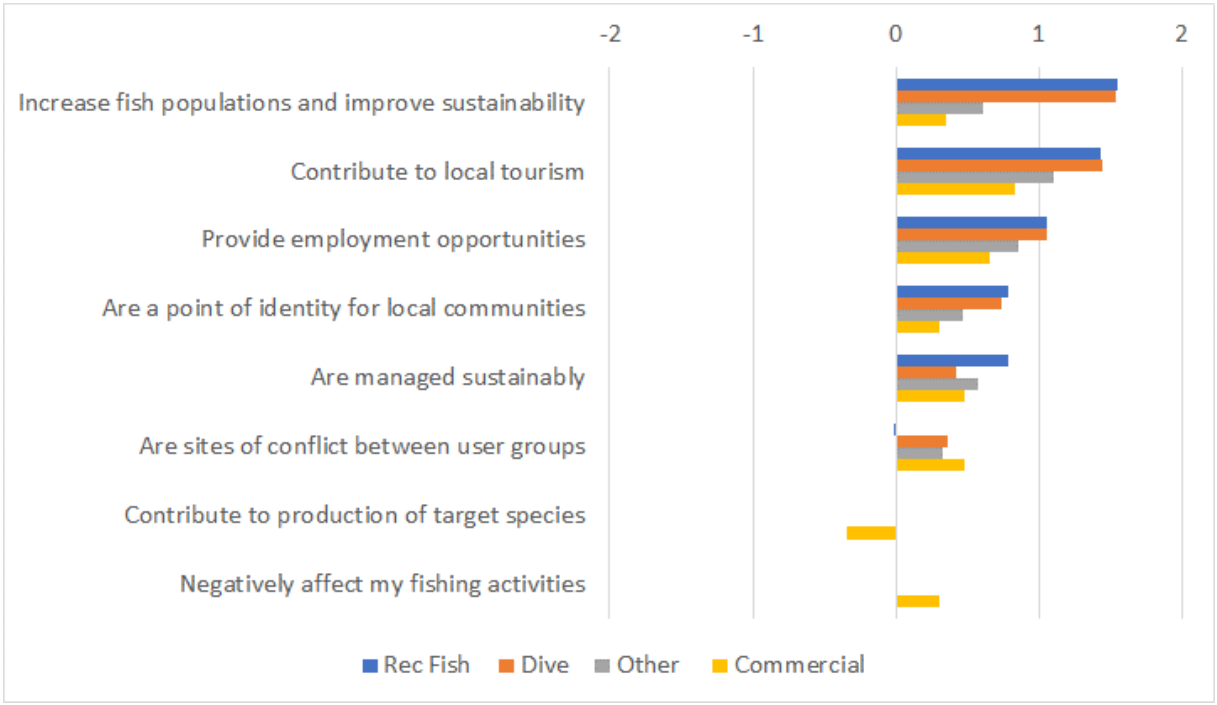
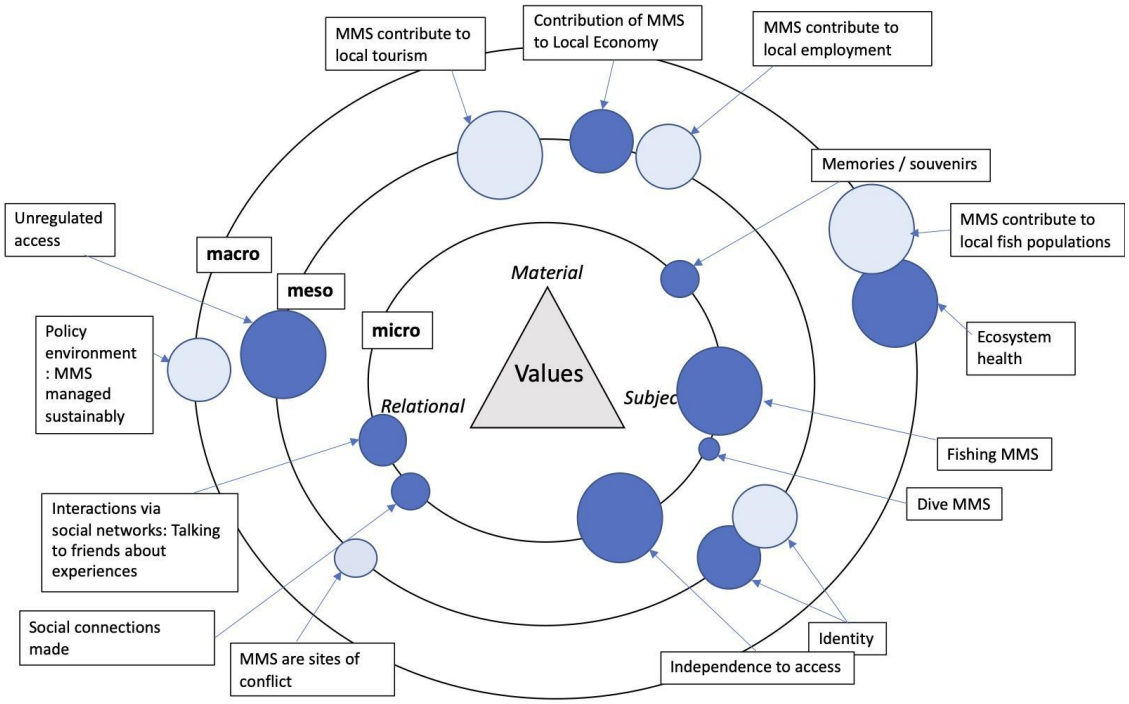
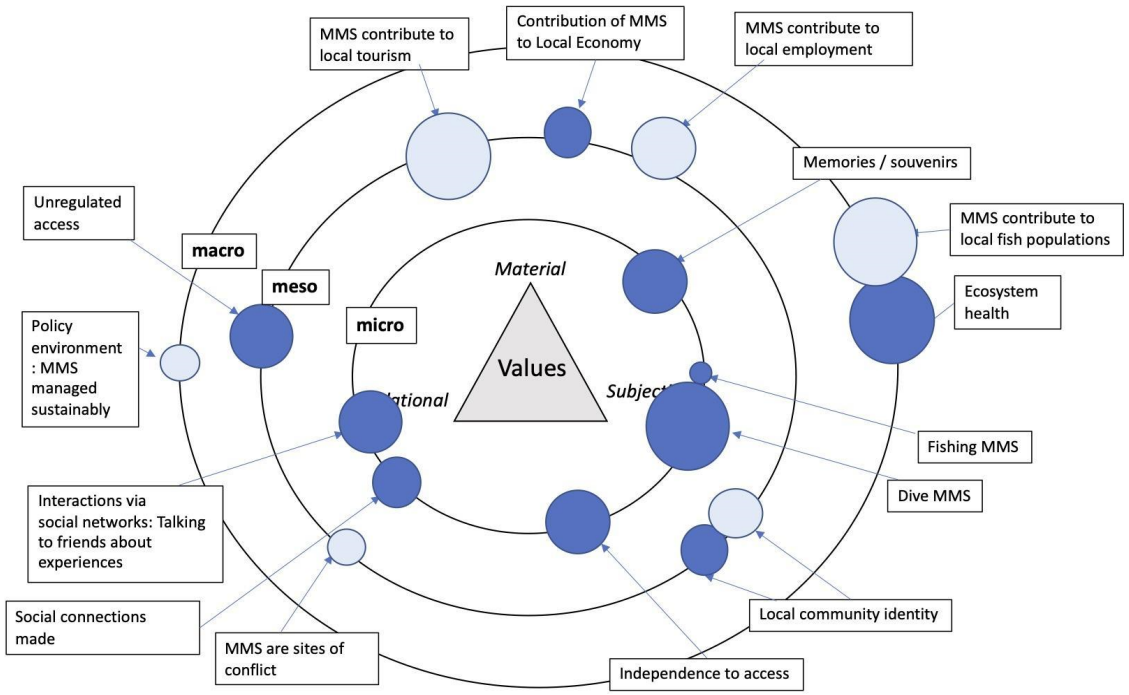


Figure 18: Relative importance of, and agreement with, statements of value and perception for MMS in Western Australia, Recreational fishing respondents.



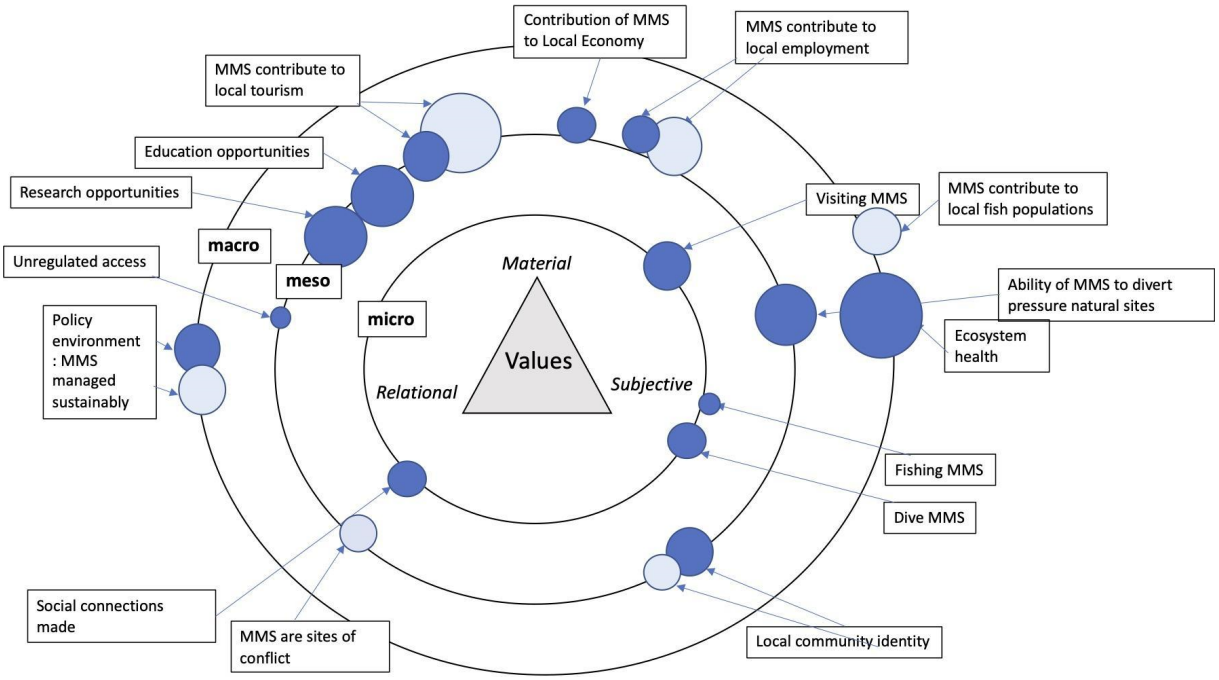
Note: Dark blue circles indicate values, light blue circles indicate perceptions. Relative size of circle denotes the average importance of the value and/or level of agreement.

Figure 19: Relative importance of, and agreement with, statements of value and perception for MMS in Western Australia, Dive respondents.



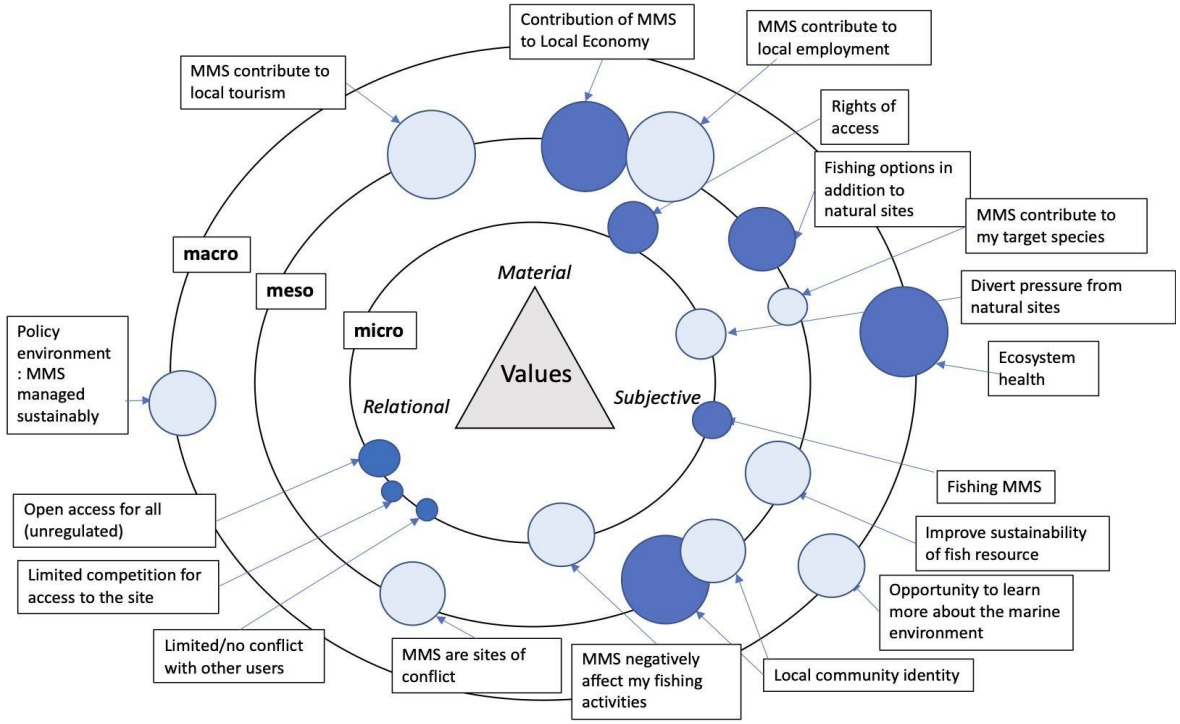
Note: Dark blue circles indicate values, light blue circles indicate perceptions. Relative size of circle denotes the average importance of the value and/or level of agreement.

Figure 20: Relative importance of, and agreement with, statements of value and perception for MMS in Western Australia, Other respondents.



Note: Dark blue circles indicate values, light blue circles indicate perceptions. Relative size of circle denotes the average importance of the value and/or level of agreement.

Figure 21: Relative importance of, and agreement with, statements of value and perception for MMS in Western Australia, Commercial fishing respondents.



Note: Dark blue circles indicate values, light blue circles indicate perceptions. Relative size of circle denotes the average importance of the value and/or level of agreement.

Results: Economic Values

This section presents the results of the different economic valuation approaches applied to the different case studies. In particular, we describe the economic use values (both in terms of expenditure and consumer surplus) for the Exmouth Integrated Artificial Reef and Thevenard Island O&G infrastructure, where there are no primary data available, and for simple primary economic data on single sites (Navy Pier, Busselton Jetty). We also present results on the use values of MMS in the context of the recreational use of multiple sites in larger regions (Geographe Bay, and the Exmouth, Coral Bay and Onslow region) where we adjusted values for the substitution of users' activities among sites within these regions. Furthermore, we describe the non-use (existence) values that the WA general public holds for environmental characteristics on O&G infrastructure in WA.

Economic values in the absence of primary data: Benefit transfer

Exmouth Integrated Artificial Reef

We estimated that the Exmouth Integrated Artificial Reef (EIAR) will increase the number of fishing trips to the Exmouth region at least by 227 and at the most by 1521 per year, depending on whether the new site primarily leads to substitution among other sites (lower value) or leads to new trips (upper value). The increase in expenditure in the region that arises from this could range from $160,000 to $1,051,000 AUD. Figure 22 below shows a graphical representation of the analysis. Panel A shows the representation of the pre-EIAR position, with the estimated demand curve for trips to the region, cost per trip ($676) and the implied consumer surplus to fishers of $3.8m. Panel B shows the maximum *additional* trips estimated, and the implied increase in consume surplus that would arise (note that for clarity these figures are not drawn to scale). Figure 23 employs a different framework, where the provision of the EIAR is assumed to increase the quality of fishing available to all fishers (i.e. the demand curve shifts up) and this causes an increase in consumer surplus and a (small) increase in number of trips. This gives an estimate of the increase in consumer surplus. The increase in the consumer surplus enjoyed by recreational fishers was estimated to vary from $114,500 to $267,000 AUD depending on which approach was taken. These are likely to be underestimates of the values generated from the reefs as they only include limited information about any additional benefits to divers, charter boat operators, commercial fisheries and no estimates on the WTP by the general public for enhanced ecological outcomes. Also, activities on artificial structures partly target the same resource and the potential values generated by any stakeholder group will depend on the access/use by others. Hence, this is important when considering the total economic value from the resource to avoid double counting.

Figure 22: Exmouth Integrated Artificial Reef: Value of the artificial reef under (A) the base scenario and (B) when the new site attracts new fishers.

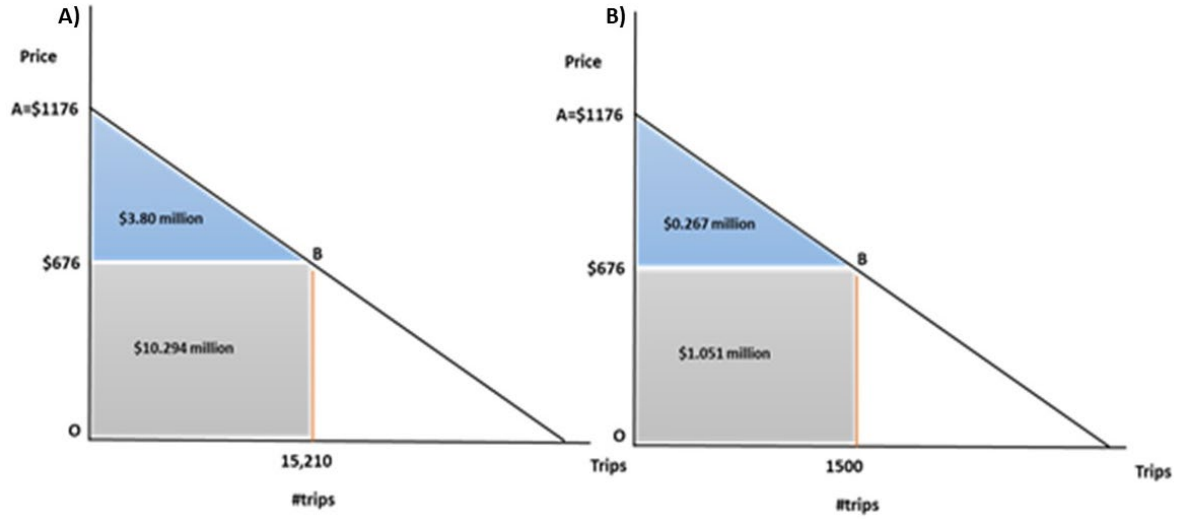
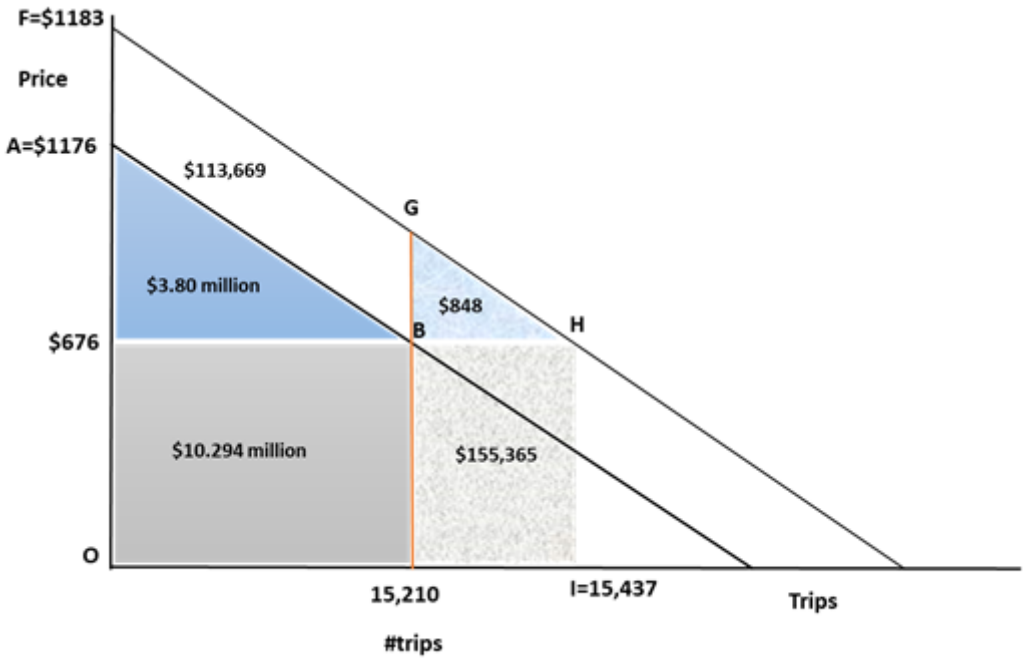


Figure 23: Exmouth Integrated Artificial Reef: Increase in value due to an improvement in overall fishing quality (movement of lines not to scale).



Thevenard O&G infrastructure

Again, we use the trip demand function, and estimates of how the provision of MMS might change it, to derive estimates of the change in consumer surplus. Again, making different assumptions leads to alterative estimates of value. Results of the approach that assumed new fishing trips would be generated suggested that the economic value of making Thevenard O&G infrastructure available would increase fishing trips in the area by between 150 to 299. This would result in extra expenditures of $80,838 to $161,676 AUD per year and an additional annual consumer surplus between $26,647 and $53,293 AUD (Figure 24, which illustrates the effect for the largest change in trips). The second approach that assumed that the availability of the new MMS would increase average catch rates, and hence increase fisher trip satisfaction, and hence consumer surplus. The

extent of that effect will depend on the level of catch rates, which are unknown. Hence, we simulate across a wide range of possible catch rate son the infrastructure, and the proportion of trips that will re-allocate to them as a result (Figure 25). The re-distribution of effort in the area suggested that the Thevenard O&G infrastructure could increase the number of recreational fishing trips to the Onslow and Thevenard Island area by between approximately 24 and 320 extra trips per year. The increase in expenditures due to the new artificial reefs could lie between $13,137 and $173,031 AUD per year and the additional consumer surplus between $10,087 and $189,872 AUD per year (Figure 25). The range of these values is very high because they depend on the catch rate which can vary highly depending on whether O&G infrastructure is being left at the current place (and therefore preserves the current biomass on it) or whether the infrastructure is being relocated and transformed into an artificial reef elsewhere. However, these values only assumed one artificial reef whereas there are nine O&G structures around Thevenard Island that could be used to create various artificial reefs which would generate higher economic benefits.

Figure 24: Thevenard O&G infrastructure: Economic value of the status quo fishing on existing sites (A) and the value of the new artificial reef(s) if the site attracts new fishers (B).

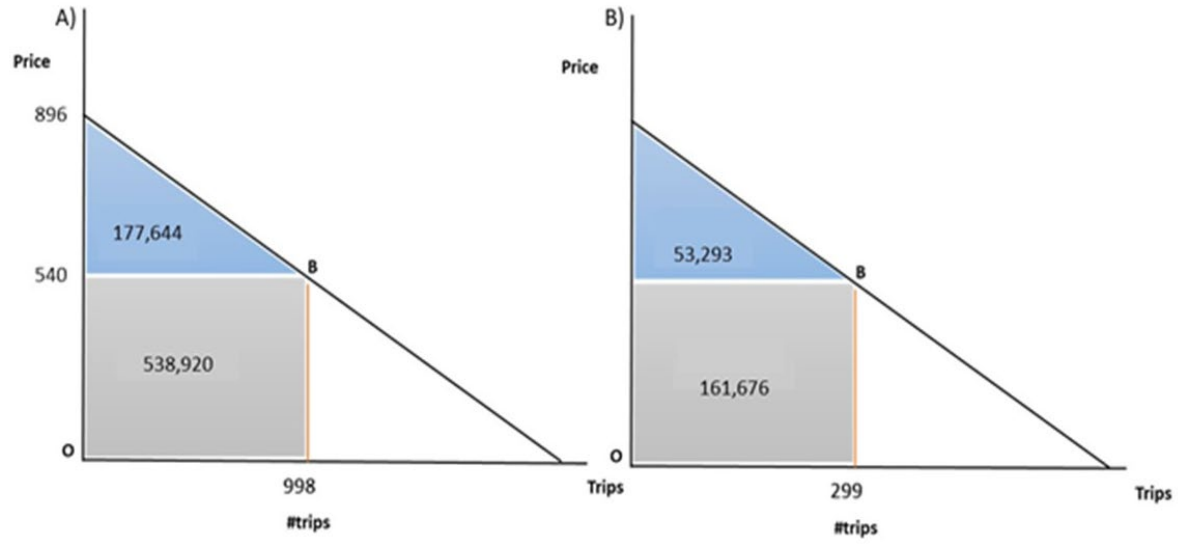
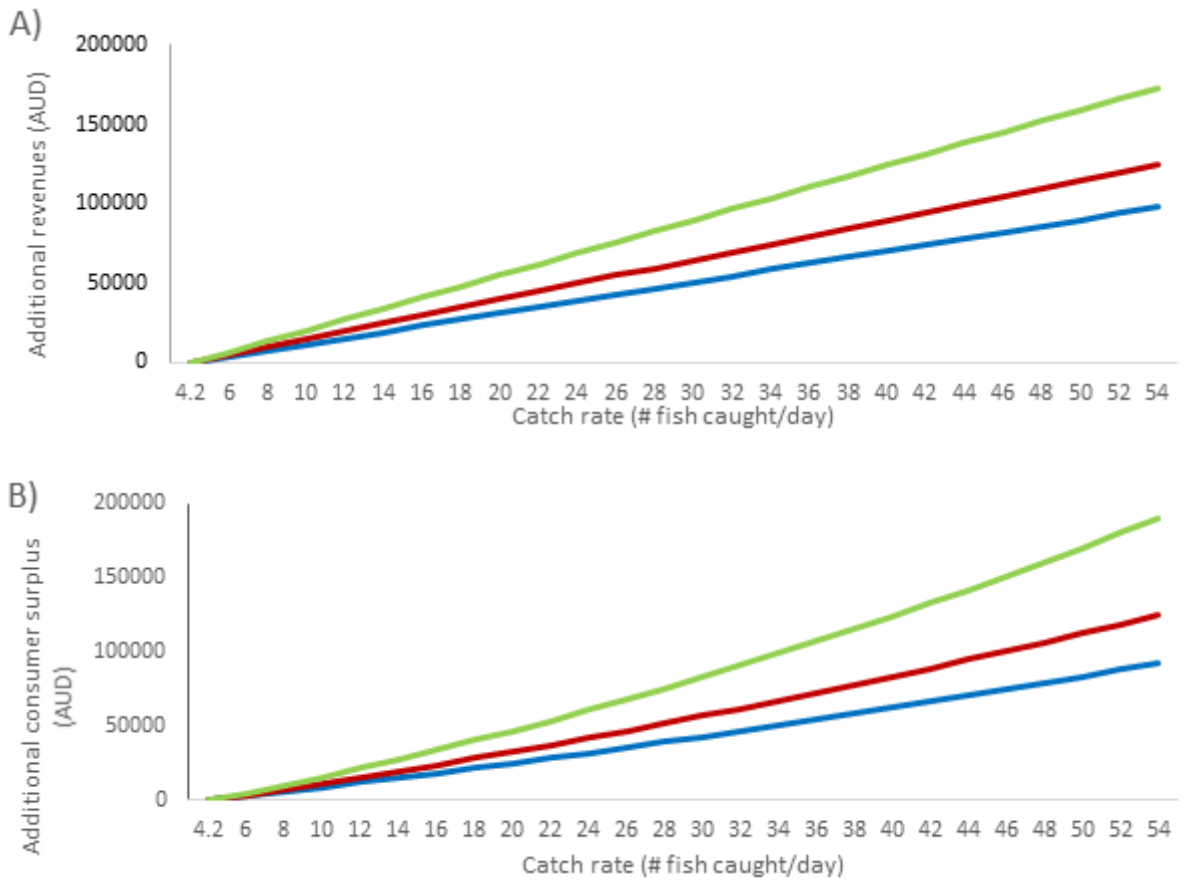


Figure 25: Relationship between catch rate and A) additional trip expenditures and B) additional consumer surplus from recreational fishers that visit Thevenard O&G structures.



Note. The colours of the lines indicate the percentage of trips going to the structures: Blue = 15%, red = 20% and green = 30% of total trips in the area.

We have also qualitatively identified economic benefits for recreational diving tourism (including scuba diving, snorkelling and free diving), charter boat operators and commercial fisheries, including aquarium fish harvest. At this stage, the available information did not allow a meaningful estimate of these values. However, we identified clear potential for the O&G structures to enhance the viability of diving tourism, charter boat operators and commercial fishing in the Onslow region.

For detailed results of these case studies, see report "The potential economic value associated with the development of artificial reefs in Western Australia" in Appendix 4.

Echo Yodel

Echo Yodel is a Woodside energy pipeline located 137 km north-west of Dampier in Western Australia.

Installed in 2001, it transported gas from the Echo Yodel gas and condensate field to the Goodwyn Alpha platform, some 23 km. The gas and condensate wells ceased production in 2012.
The current proposal for decommissioning permanently plugs and abandons the two production wells (Yodel-3, Yodel-4 and Capella-1), including removal of associated well infrastructure and involves removal of the 23 km umbilical. At the time of writing the proposed decommissioning of Echo Yodel infrastructure was the subject of the regulatory assessment and approvals process under

the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009. The Echo Yodel pipeline will be decommissioned in situ.

The Echo Yodel infrastructure has been in place for 18 years. In that time, it has provided habitat and support for a range of marine fauna. Recent studies identified a range of commercially relevant species that have established along the pipeline (Bond et al., 2018). Commercial fishers do fish in the area (Bond, 2020). They are participants in the Pilbara Trap fishery, which harvests a range of demersal species.

The economic value of the infrastructure was evaluated by inferring what the implications are for profits of current fishers if it were removed. This required some assumptions about allocation of effort, catch and economic parameters under the two scenarios, but it is important to note that it is the change in profits that are important, and which may be influenced by changes in catch (both level and quality) and/or changes in costs. The impact of the pipeline therefore comes down to fishing cost on and away from the pipeline and the share of catch that is currently on the pipeline. We estimated that this value may be relatively low ($9,121 per year).

For detailed results, see Appendix 9 "Economic impact of removing Echo Yodel Pipeline on commercial fishing".

Economic use values - Single site-specific

Zonal travel cost model: Exmouth Navy Pier

We collected a total of 153 valid responses through the Exmouth Navy Pier survey. Respondents' characteristics are shown in Table 17. The survey revealed that the average expenditure for one day diving in the Exmouth region is $205 AUD. With approximately 3000 divers visiting the Navy Pier per year, we estimated an aggregate annual expenditure of $615,000 AUD.

Table 17: Respondents' characteristics (n=153).

Respondents' characteristics	Value	Range
Average age (years)	39 (SD 12.17)	22-72
Gender (% female)	45.4	
Zone (%)		
Western Australia	36.8	
Other states of Australia	23.7	
Oceania	0.7	
Asia	2.6	
Europe	25.7	
America	10.5	
Average number of trips (# of trips/year)	1.9 (SD 4.4)	1-50

Average trip duration (# of days/trip)	8.00 (SD 9.90)	2-90
Average expenditure on diving (AUD)	205	
Average total trip expenditure (AUD)	2411 (SD 2086)	150-15000

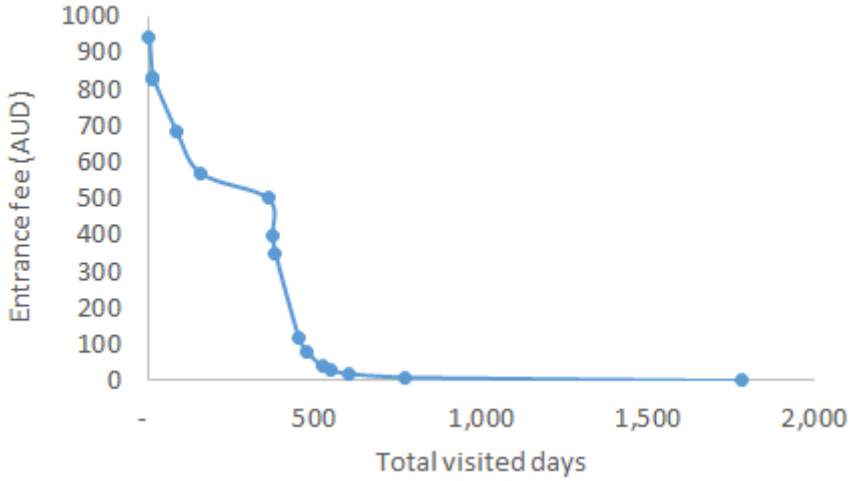
The travel cost model results (Table 18) show the estimated parameters of the relationship between the costs of getting to the region and the per capita visitation rate. Based on this equation, we extrapolated how aggregate visitation would change for (simulated) increases in price, which is essentially deriving the demand curve for diving in the Exmouth region. We assumed that all respondents have the same 'choke' price of $978 AUD (being a combination of their current travel costs and the simulated increase in price due to an 'entrance fee') at which demand would fall to zero. We derived this value as approximately double the amount of travel costs from the zone with the highest cost (America) (Cohen et al. 2016). This process led to a segmented aggregate demand curve, as shown in Figure 26, where 'kinks' occur as segments leave the market entirely as the hypothetical 'entrance fee' increases. The area under the aggregate demand curve represents the consumer surplus of our sample that arose from the 1779 trip days that they took (i.e. the benefit that they enjoyed over and above the costs of getting to the location). The estimated consumer surplus for one day diving in the Exmouth region is $136.39 AUD.

This estimate is derived for dive trips to the Exmouth region as a whole, in any area. We assumed that this value also applied to dives at the Navy Pier. With approximately 3000 divers visiting the Navy Pier per year, this resulted in an aggregate consumer surplus of $409,170 AUD/year.

Table 18: Summary regression results of ln(stay) on the inverse of travel cost.

Variable	Coefficient	Std. Err.	P-value
1/Travel Cost	262.933	64.517	0.015
Intercept	-1.330	0.796	0.170
R^2	0.806		
Observations (zones)	6		

Figure 26: Demand curve for diving in the Exmouth region.



Individual Travel Cost Model: Busselton Jetty

A total of 211 usable responses from people living in WA gave information on their total number of trips to Busselton Jetty in 2019. 51% were resident in Busselton, and the median number of trips was eight, although a significant proportion (14%) said they went more than 50 times in the year. Using a censored negative binomial model, we found a significant negative relationship between the costs of getting from their place of residence to the Jetty, as reported in Table 19 (i.e. the estimated coefficient of -0.028 implies that number of trips falls as travel costs to the site increases).

Surveys revealed that the median expenditure associated with one visit on the Busselton Jetty per person is $12 AUD. We estimated the consumer surplus for one visit on the Jetty to be $36 AUD, which, as noted above, is derived in this form of travel cost model as minus one times the inverse of the coefficient on the travel cost (i.e. -1/(-0.028)). With approximately 535,115 visitors to the Busselton Jetty per year, this resulted in an aggregate annual expenditure of $6.4 million AUD and a consumer surplus of $19.26 million AUD per year. Note that in this case the estimates of the surplus value (that attained by the user over and above costs) is substantially greater than the expenditure estimate.

Table 19: Summary regression results of number of trips on the estimated travel cost: Busselton Jetty.

Variable	Coefficient	Std. Err.	P-value
Travel Cost	-0.028	0.007	<0.001
Intercept	2.488	0.088	<0.001
Dispersion	-0.251	0.118	0.034
Observations	195		

Note. For all details on the results, see the full report "The economic value of the Exmouth Navy Pier and Busselton Jetty, Western Australia" in Appendix 5.

Economic use values - Choices across multiple sites

Descriptive statistics

The random utility survey yielded 174 valid responses, out of which 123 were from recreational fishers and 51 from divers. We found that for recreational fishers, the level of use of our case study regions decreased with increasing distance from Perth. The most visited area was Geographe Bay where recreational fishers spent about almost two thirds and divers about 40% of their trips. In the Exmouth region, one third of fishing trips and 57% of dive trips took place, hence Exmouth was the most visited region for divers. Only 4% of fishing and diving trips took place in the Onslow region.

In Geographe Bay, recreational fishers indicated 307 places they visited, out of which 94 (30.6%) were on MMS. Divers used MMS relatively more with 40 out of 61 locations (66.7%) being on MMS (Figure 27: note that the heat maps represent the percentage of total visitation within the sample by location). In the Exmouth Region, use of MMS was overall lower than in Geographe Bay. Recreational fishers added 161 locations, out of which 25 (15.5%) were on MMS and about 12.2% of divers' locations (11 out of 90) were taking place on MMS (Figure 28). This could be explained by the fact that there is only one artificial reef and one jetty in the Exmouth region whereas Geographe Bay has five different MMS available in a smaller area. We had very small numbers of visitors to the Onslow Region (Figure 29) and the heat maps should be interpreted with this in mind. Recreational fishers indicated 21 locations they visited, four being on MMS. Divers added six locations, three being on MMS. Coral Bay has no MMS, so all 83 trips recorded were taking place on natural sites (Figure 30).

Figure 27: Frequency of trips for boat based (A) recreational fishing (n=307) and (B) diving (n=61) in Geographe Bay.

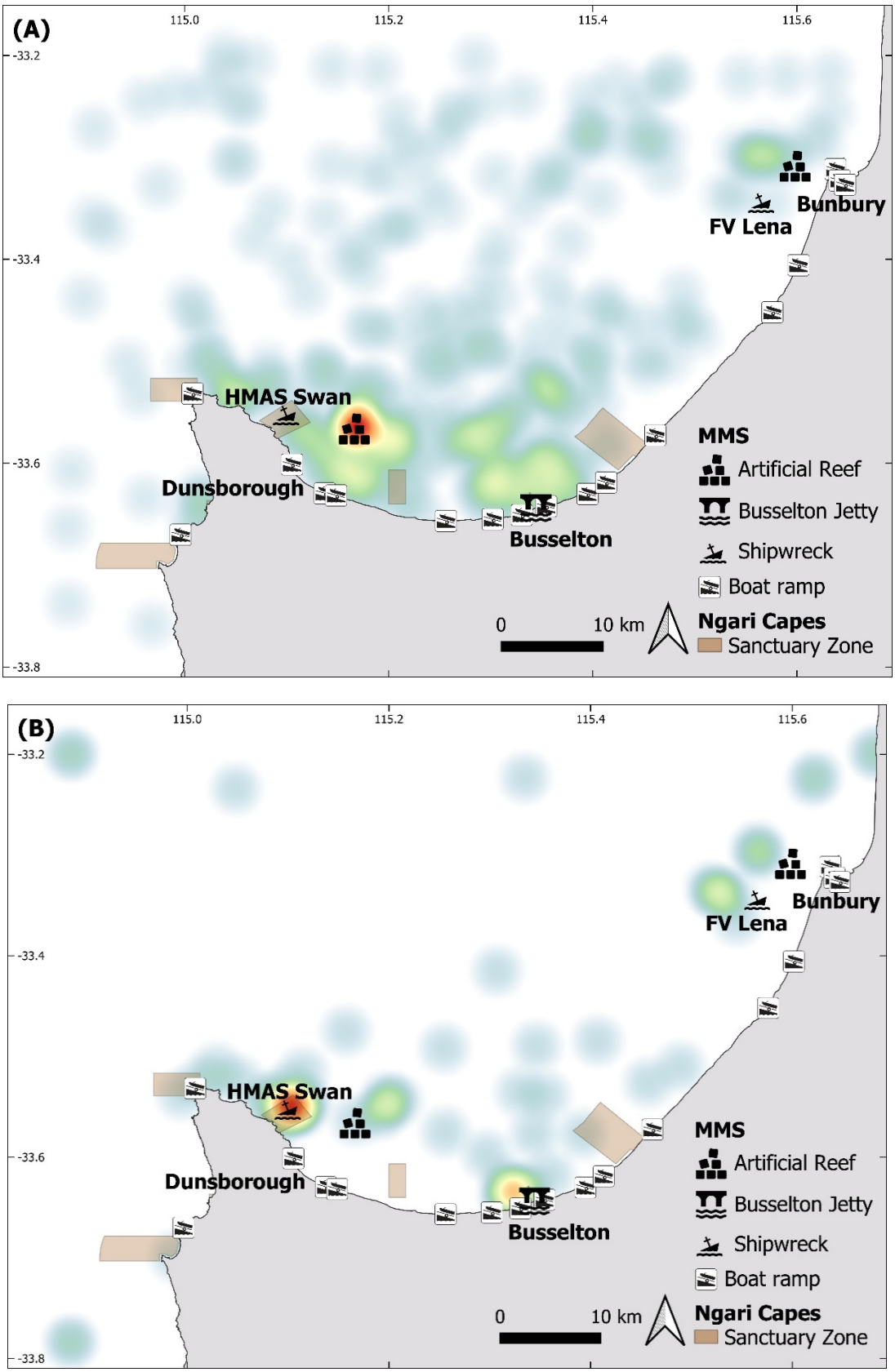
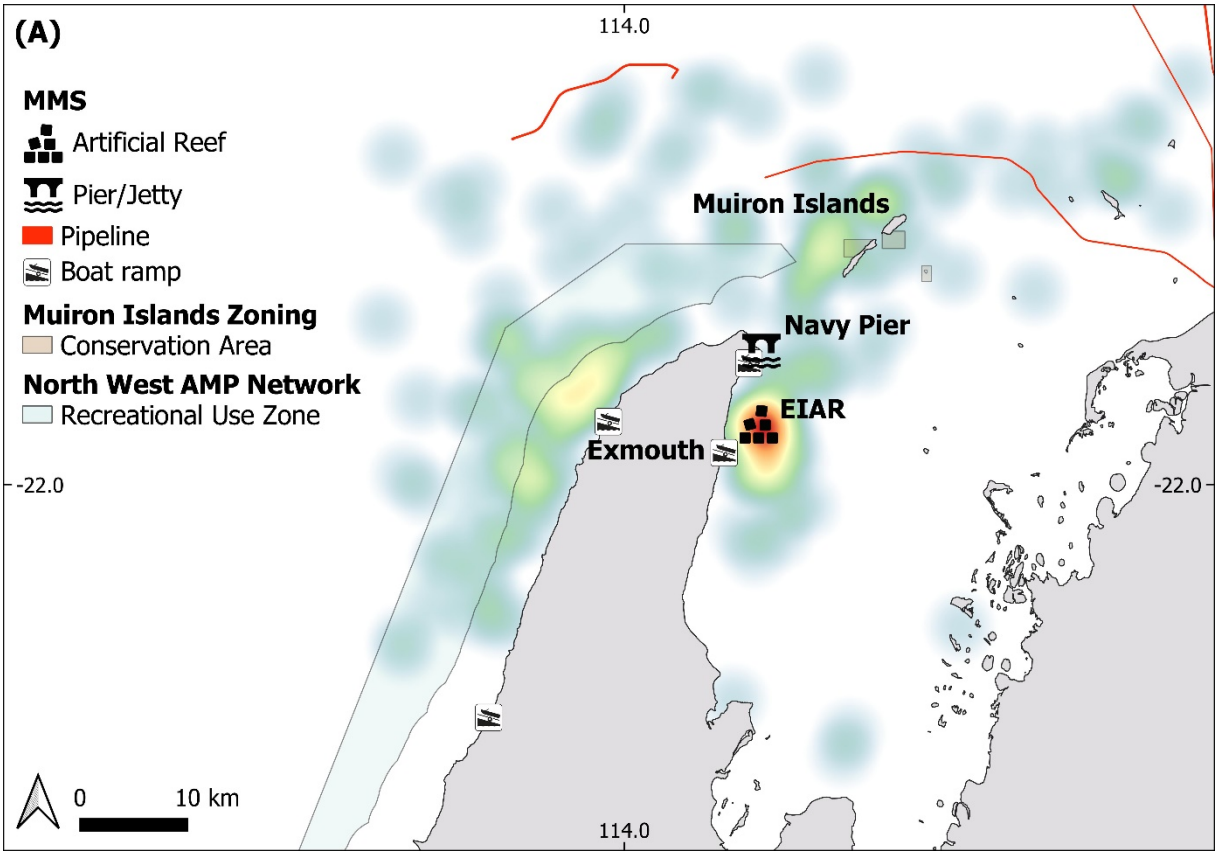


Figure 28: Frequency of trips for boat based (A) recreational fishing (n=161) and (B) diving (n=90) in the Exmouth region.



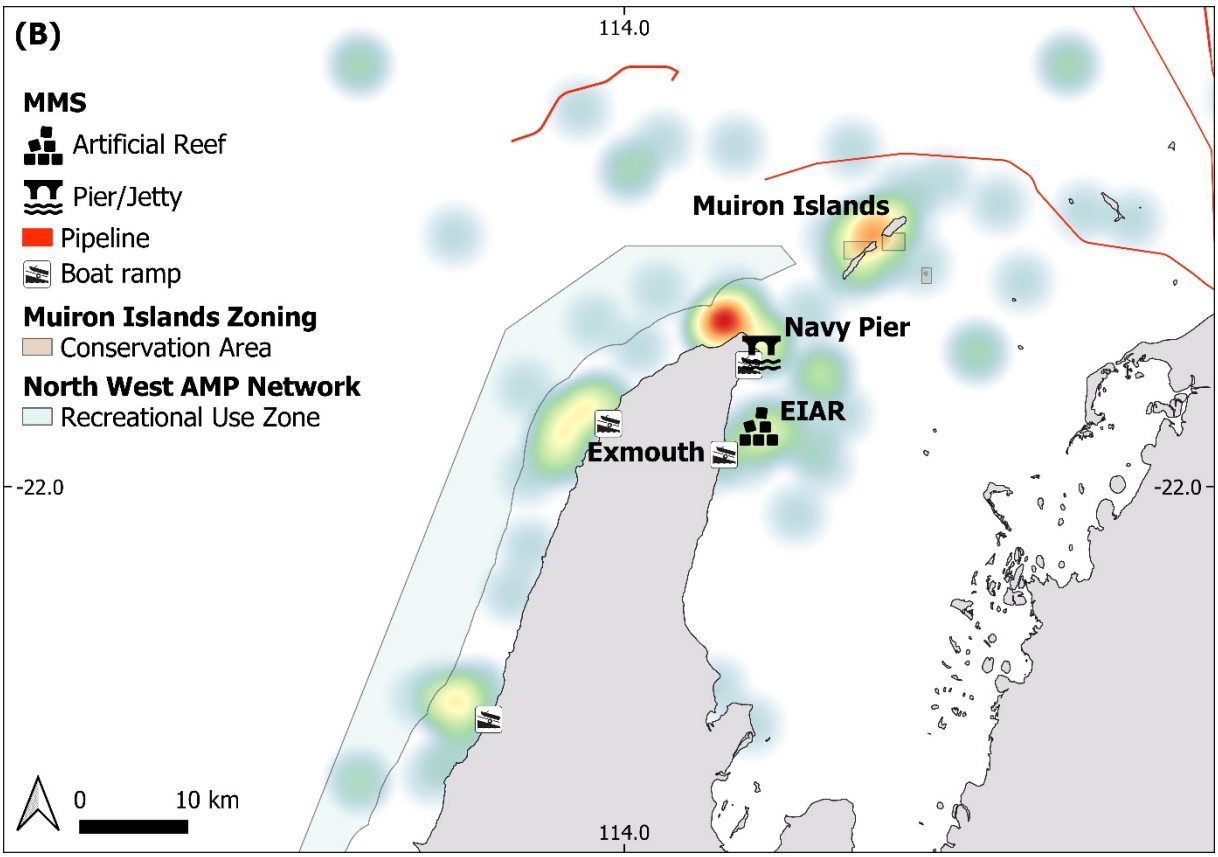


Figure 29: Frequency of trips for boat based (A) recreational fishing (n=21) and (B) diving (n=6) in the Onslow region.

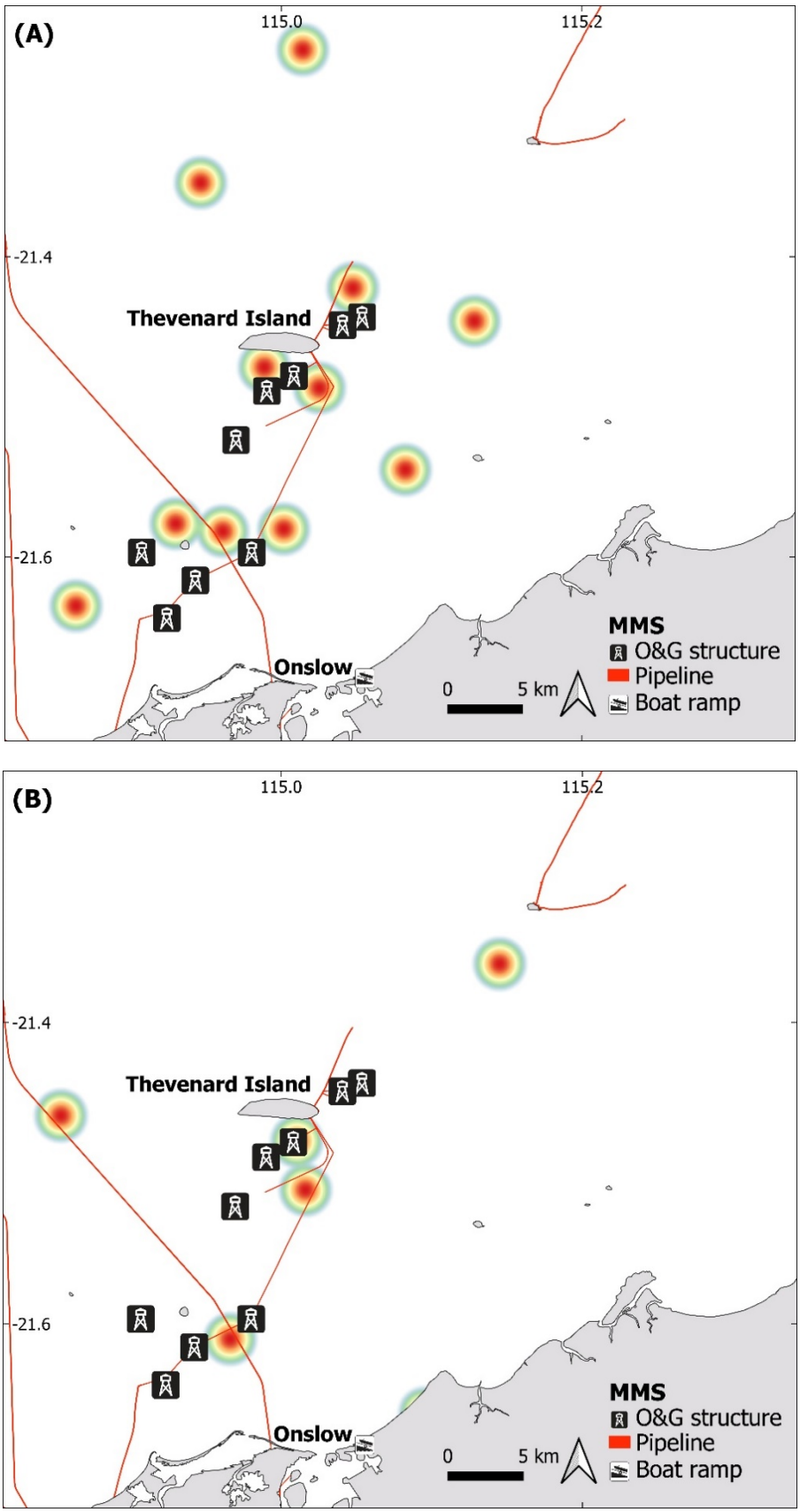
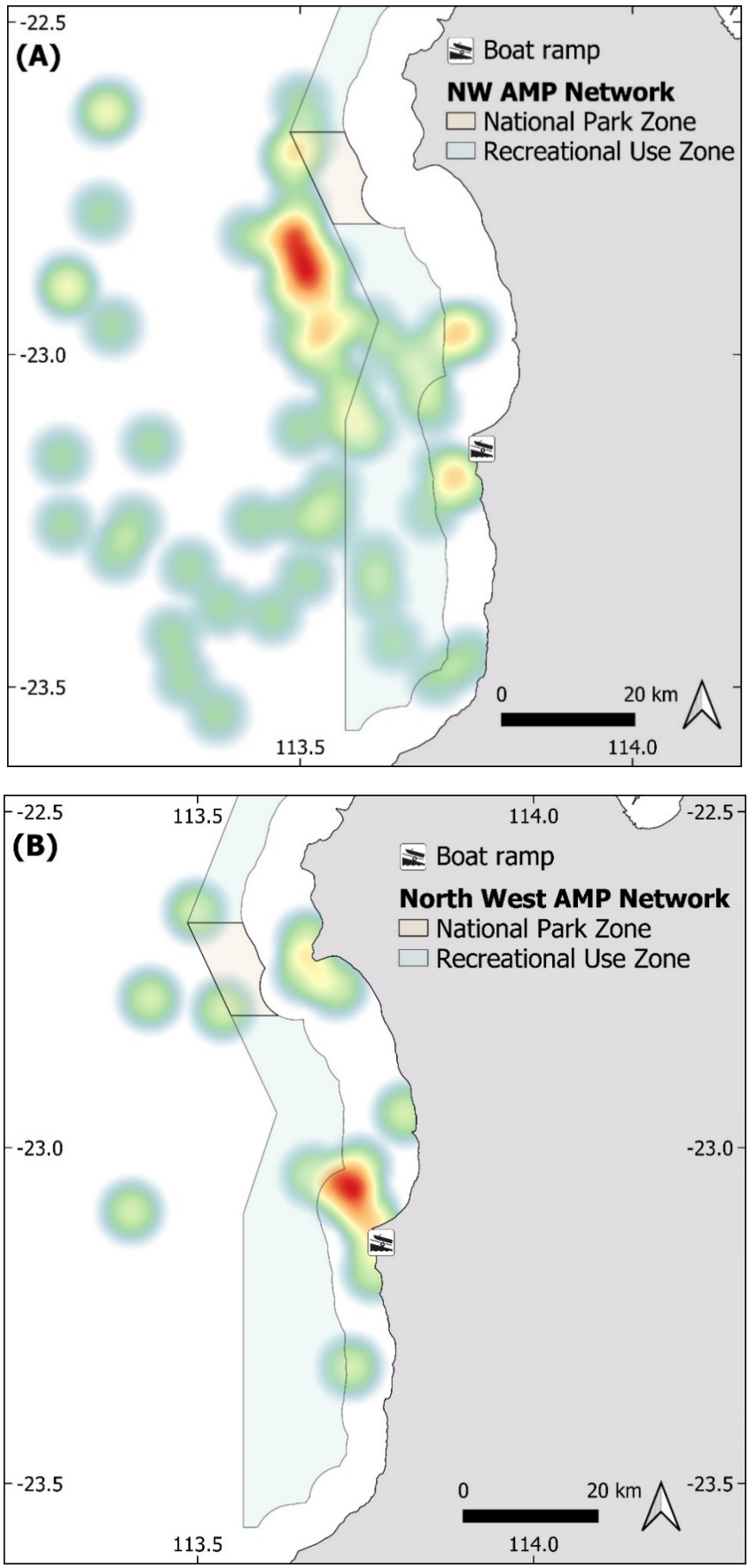


Figure 30: Frequency of trips for boat based (A) recreational fishing (n=72) and (B) diving (n=11) in Coral Bay.



Random utility model

We estimated a random utility model for both recreational fishers and divers (Table 20). This table reports the estimated coefficients of the utility function that underlies the choices made. They can be interpreted as 'scaled marginal utilities' i.e. the change in utility that arises from a unit change in the attribute but they have no directly interpretable units of measure. However, ratios of coefficients are interpretable, as the marginal rate at which a respondent would substitute one attribute for another. As expected from economic theory, the travel cost coefficient had a significant and negative effect in both models. Artificial reefs influenced site choice for recreational fishers strongly and positively, whereas there was a positive but not significant effect for divers. The Busselton Jetty influenced strongly and positively the site choice of divers and fishers. Shipwrecks influenced both recreational fishers' and divers' site choice positively, but this effect was only significant for divers. This is not surprising because both the Lena and the Swan shipwrecks are no-take zones. However, recreational fishers might still benefit from spill-over effects from these zones. Another possibility is that respondents combine different activities and go fishing in the surroundings of the wrecks as well as dive on the wrecks during one trip. In general, some recreational fishers indicated to have fished within no-take zones. However, this might be due to an inaccuracy of clicking on the map rather than an illegal activity.

The area of the grid cell and the distance from shore also positively affected site choice for both user groups. Moreover, fishers and divers had a preference for sites more distant from shore. This result might be explained by users trying to avoid overcrowding in areas closer to shore. It might also be an indicator of overfishing in areas closer to shore. Water depth was not significant and is therefore not reported here.

Results of this model also revealed the WTP for MMS types for those who actually visit them and hence did not account for the substitution effect. Given that shipwrecks are closed to fishers it is not surprising that recreational fishers' WTP for artificial reefs was about twice that for shipwrecks. Also, the WTP of divers for jetties was about twice that for shipwrecks.

Table 20: Results of the random utility model for recreational fishers' and divers' site choice in Western Australia.

Variable	Recreational fishers			Recreational divers		
	Coef.	Std. Err.	P-value	Coef.	Std. Err.	P-value
Travel cost	-0.117	0.009	0.000	-0.117	0.012	0.000
Artificial reef	1.126	0.335	0.001	0.428	0.536	0.425
Shipwreck	0.353	0.358	0.325	2.113	0.559	0.000
Jetty	1.391	0.408	0.001	2.729	0.710	0.000
Area	0.007	0.002	0.000	0.008	0.002	0.000
Distance from shore	0.022	0.010	0.027	0.020	0.012	0.105
Number of trips	130			79		
Respondents	70			40		
Log-likelihood	-316.881			-179.942		
WTP artificial reef	-9.620	3.014	0.001			
WTP shipwreck				-18.045	5.282	0.001
WTP jetty	-11.909	3.725	0.001	-23.311	6.786	0.001

Welfare impact of MMS

It is possible to use this model to simulate what would happen if one introduces or removes MMS from particular cells. Adding an MMS would increase the value of visiting that cell, cause a reallocation of effort and lead to an overall improvement in welfare of fishers/divers. It is possible to quantify (in $ terms) the overall improvement in welfare of all fishers/divers as a result of the change. We estimated the value associated with existing MMS in the four regions by calculating the change in welfare (in AUD per trip) that occurs when MMS are hypothetically removed (Table 21). The simulation of site choice under the removal scenarios included the redistribution of users across the region, also called the substitution effect. Therefore, the values associated with these structures were lower than the WTP of respondents when not taking substitution into consideration.

For recreational fishers, the removal of the Dunsborough artificial reef (DAR) had the highest welfare impact, followed by removing the Busselton Jetty (BJ). For divers, the removal of the Swan wreck (SW) had the highest welfare impact, followed by the Busselton Jetty (BJ). Overall, the removal of MMS had a higher loss in welfare on divers than on fishers.

As expected, the sum of welfare changed when removing MMS in Geographe Bay separately is lower than when removing all MMS in Geographe Bay at once for divers. This is because the sum of the welfare change of all MMS reflects the welfare change where users still can substitute among

different MMS. Conversely, in the scenario that removes all MMS at once, users can only substitute their sites with non-MMS sites. However, fishers' loss in welfare as the sum of removing all MMS separately was higher than removing them all at once. We suspect that this is because there are two MMS (the Swan wreck and the Dunsborough artificial reef) in the same grid cell. The model suggests that dropping both together was less harmful than the sum of dropping each in turn. However, this likely depends on the number of MMS per cell (having a high number of MMS in single cells probably will cause the substitution effect to overcome the marginal effect of two MMS in one cell).
We also simulated the site choice and associated welfare changes under scenarios in which we added MMS to the study regions. We used MMS types that were significant to recreational fishers (artificial reefs) and divers (wrecks) as a proxy. It is noticeable that these two structure types have different characteristics: artificial reefs give access to recreational fishers and divers, however divers rarely use these structures due to the incompatibility of the two activities. Wrecks are only open to divers but have shown to have a positive effect on recreational fishers as well (Table 21). Consistent with the negative travel cost variable, the added value of a MMS to a grid cell closer to boat ramps (G28) was much higher than when adding a MMS further away (G25) for both recreational fishers and divers.

Lastly, we simulated different scenarios of opening access to fishers and/or divers to the Thevenard O&G infrastructures (Table 21). Again, we used the coefficients from "artificial reefs" and "wrecks" as a proxy because we had no estimates for O&G infrastructures. Results indicated a decreasing marginal utility with additional MMS (i.e. additional structures are valued, but at a decreasing rate as more structures are added). For example, divers and recreational fishers had a higher value per structure when opening the access to two structures (AR2 and W2) than when giving access to all nine structures (AR9 and W9). This result was also influenced by the fact that the scenario AR2 and W2 gave access to the two structures closest to shore which reduced travel costs. The scenario that combined O&G infrastructures that are significant to fishers (artificial reefs) with those that are significant to divers (wrecks) (AR4W5) had the most equitable benefits.

Table 21: Hypothetical scenarios for MMS in Western Australia and the associated change in welfare for recreational fishers and divers

Scenario	Description	Change in rec. fishers' welfare (AUD/trip)	Change in divers' welfare (AUD/trip)	Aggregate change in rec fishers' welfare (AUD/year)	Aggregate change in rec divers' welfare (AUD/year)
Geographe Bay					
SW	Remove Swan Wreck	-0.27	-0.75		
LW	Remove Lena Wreck	-0.07	-0.36		
DAR	Remove Dunsborough AR	-0.68	-0.21		
BAR	Remove Bunbury AR	-0.20	-0.01		
G25	Add MMS in Geographe Bay (cell 25)*	0.04	0.01		
G28	Add MMS in Geographe Bay (cell 28)*	0.42	0.19		
Sum of removing all MMS separate		-1.67	-1.89		
Remove all MMS at once		-1.59	-1.97		
Coral Bay					
EAR	Remove EIAR	-0.20	-0.09	-3,042	
EW	EIAR diver access only	-0.16	0.95	-2,434	
E37	Add MMS (cell 37)*	0.12	0.15	1,825	
Onslow region					
AR9	Access O&G infrastructure: 9 "artificial reefs"	1.19	0.10	1,188	
W9	Access O&G infrastructure: 9 "wrecks"	0.21	1.06	210	
AR4W5	Access O&G infrastructure: 4 "artificial reefs" and 5 "wrecks"	0.50	0.60	499	

AR2	Access O&G infrastructure: 2 "artificial reefs"	0.53	0.05	529	
W2	Access O&G infrastructure: 2 "wrecks"	0.09	0.54	90	

* *"artificial reefs" for recreational fishers and "wrecks" for divers*

Our results were consistent with previous studies that have analysed the access value for recreational fishers to sites along the coast of Western Australia. The importance of MMS to recreational fishers in this area was highlighted when comparing the welfare impact of removing all recreational fishing sites in Busselton ($-3.76 AUD) (from (Raguragavan and Hailu, 2013) to the sum of welfare loss from removing all MMS in the area ($ -1.40 AUD) (from Table 20 above, for artificial reefs only). In other regions, such as Exmouth, such a comparison suggested that the relative importance of MMS to recreational fishers was lower ($-6.16 AUD for removing all sites (from (Raguragavan and Hailu, 2013)) compared to $-0.20 AUD for removing the EIAR). The access value of the Onslow region was relatively low ($2.95 AUD; (Raguragavan and Hailu, 2013)), hence, opening access to the O&G infrastructures could increase the welfare of users significantly. Conversely, adding an MMS in Coral Bay would not add much to the welfare of users.

For all details on the results, see full report "The use value of man-made marine structures in Western Australia: A random utility model" in Appendix 6.

Economic existence values: Community preferences

Descriptive statistics

The survey yielded a total of 392 valid responses, drawn from the general Western Australia population. 'Protest' respondents i.e. those who *always* chose the complete removal option (status quo) in all choice sets, were excluded from the analysis of the choice data, although their answers were retained in the descriptive statistics, and should be included when considering the proportion of the sample who would accept a particular reef option over complete removal. This is because they are not revealing any information about the value of the attributes of the reef, as they are making their choice on some other heuristic. Choices of the complete removal that were reported by those making a mixture of choices were included. Overall, respondents in the sample reflected the demographic structure of the Western Australia population (Table 22).

Table 22: Demographic characteristics of survey respondents.

Demographics	Sample (%)	Western Australia population (%)
Gender		
Male	50	50
Female	49	50
Age		
18-30	17	23
31-45	28	28
46-60	27	25
61-75	20	17
Over 76	8	7

Source: Australian Bureau of Statistics (2016)

Social License to Operate

The SLO was measured one a scale from one to five, higher scores indicate a higher SLO. The various questions regarding the different aspects of SLO were combined into two measures of SLO: the "extended economic legitimacy" and the "social legitimacy". The relative distributions of the two measures (Table 23) indicate that respondents tend to agree that the O&G sector contributes to the economy of Western Australia, whereas they neither agree nor disagree on average with the measure of "social legitimacy".

Table 23: Summary of the "Extended economic legitimacy" and the "Social legitimacy" measures.

	Mean	Standard deviation	Number of observations
Extended economic legitimacy	3.88	0.734	392
Social legitimacy	3.15	0.805	392

Discrete choice experiment

9.4% of respondents opposed rigs-to-reefs under any scenario presented to them. The remaining proportion revealed preferences for rigs-to-reefs depending on the individual's characteristics and the nature of the reef presented (Table 24). The reported coefficients can be interpreted as the scaled marginal utility associated with an attribute i.e. the change in utility that would arise for a unit change in the attribute. They have no interpretable units *per see*, but ratios of parameters do, as they indicate the trade-offs between two attributes that a respondent is prepared to make. In particular, the ratio of attribute parameter to a cost parameter gives the value of the attribute in monetary terms. Significance of the parameter estimates is determined by conventional measures of statistical significance (p values) or the 95% confidence intervals.

Preferences were higher towards reefs that could provide either habitat for threatened species, increased fish biomass, production of fishes, and access for divers, or increased revenue for the State budget. However, preferences for rigs-to-reefs were reduced if liability lay with the Government, or social licence granted to the O&G sector was low.

Table 24: Conditional logit model, full model.

Choice	Coef.	Std. Err.	P-value	95% Conf. Interval
Status Quo	0.583	0.433	0.179	-0.267 1.432
Habitat	0.180	0.117	0.124	-0.050 0.409
Biomass	0.087	0.104	0.404	-0.117 0.290
Production	-0.011	0.122	0.925	-0.251 0.228
Access to divers	0.037	0.122	0.764	-0.203 0.277
Access to fishers	-0.329	0.122	0.007	-0.567 -0.090
Liability with government	-0.138	0.084	0.000	-0.301 0.026
Joint liability	-0.815	0.107	0.100	-1.024 -0.606
Attributes interacted with SLO and attitudinal questions				
SQ*EEL	-0.429	0.100	0.000	-0.625 -0.232
HAB*ATTHAB	0.619	0.112	0.000	0.399 0.839
BIO*ATTBIO	0.298	0.106	0.005	0.090 0.506
PROD* ATTPROD	0.399	0.147	0.007	0.111 0.687
ACCDIVER*DIV	0.442	0.164	0.007	0.121 0.762
ACCFISHER*FISH	0.490	0.132	0.000	0.230 0.750
REV*ATTREV	0.003	0.001	0.003	0.001 0.005
REV* NOATTREV	0.002	0.001	0.161	-0.000 0.004

Number of observations = 6,354; LR chi^2 (9) = 906.71; Pseudo R^2 = 0.1948;
Log likelihood = -1873.5072

Probability of accepting rigs-to-reefs

We estimated the probabilities that a respondent would accept the reef option depending on the attributes of the reef as well as on the level of extended economic legitimacy (EEL) that respondents granted to the O&G sector (Table 25). We show the latter as the range from 1 (does not grant EEL) to 5 (grants the highest EEL).

The probabilities of the 'base reef' were obtained assuming that the reef does not provide habitat for threatened species, has 0.5 tonnes of fish biomass, the fishes are attracted to the rig, there is no access for anyone, the company is liable, it provides $100 million AUD in revenue to the State budget, and the respondent does not attend to any of the attributes. The results revealed that the probability of choosing a rig-to-reef with these characteristics decreases by 34 percentage points from 0.85 for someone granting an EEL of 5, to 0.51 for someone that does not grant EEL. A higher probability of accepting a reef with a higher EEL was found for all attributes.

All attributes that described an environmental improvement, namely the provision of habitat for endangered species, the increase in biomass and the production of fish (opposed to the attraction of fish) increased the probabilities of respondents accepting a rig-to-reef.

For the access to the reef for divers, the results presented a very small increase (0.01) in the probability of choosing the reef option when the respondent is not a diver, but a high increase in the probabilities for those who are divers. Conversely, the probability of choosing the reef option when the access is allowed for fishers substantially decreases if the respondent is not a fisher, and slightly increases when the respondent is a fisher.

The results regarding the liability attributes revealed that, compared to the base reef, there is a substantial decrease (0.19) in the probability of choosing the reef when the respondent does not

grant EEL and the liability lies with the Government; and a smaller decrease in the probability for someone granting the higher degree of EEL (0.13). In the case of the liability being shared between the Government and the company, the results also showed a decrease in the probabilities, but to a lesser extent.

Finally, the revenue attribute revealed that the probability of choosing the reef option increases when higher amounts of revenue are paid by the company to the State budget (when considering those who attended to revenue).

Table 25: Probabilities of choosing the rig-to-reef option depending on different levels of attributes and degree of economic legitimacy.

	Levels of economic legitimacy	
Attributes	1	5
1. Base reef	0.51	0.85
2. Biological		
a. Habitat & attend to habitat	0.70	0.93
b. Fish biomass (tonnes) & attend to biomass		
0.5	0.55	0.87
1.5	0.64	0.91
c. Fish production & attend to fish production	0.61	0.90
3. Access to the reef		
a. For divers, if		
Not a diver	0.52	0.86
Diver	0.63	0.90
b. For fishers, if		
Not a fisher	0.43	0.81
Fisher	0.55	0.87
4. Socioeconomic		
a. Liability		
Government	0.32	0.72
Shared	0.48	0.84
b. Revenue (AUD million) & attend to revenue		
100	0.55	0.87
160	0.60	0.89

For full results, see the full report “Community acceptance of rigs-to-reefs in Western Australia” in Appendix 7.

Summary of Economic Values

We found evidence for the economic value of MMS throughout the different methods used in this study. We estimated both expenditure and consumer surplus measures associated with the MMS of the four case studies. While the expenditure indicated the contribution that an MMS makes to a local economy, the consumer surplus revealed the benefits that people gain from MMS, both from the direct use as well as from the existence of marine life on MMS. The sum of these measures is the total economic value associated with MMS.

We found that within the survey responses recreational fishers used the Geographe Bay region the most, followed by the Exmouth and Onslow region. Conversely, divers made most trips to Exmouth, followed by Geographe Bay and Onslow. Overall, divers used MMS more (34%) than recreational fishers (25%). Divers mainly used jetties and shipwrecks whereas recreational fishers mainly used purpose built artificial reefs.

We used three alternative approaches to estimate the potential value of decommissioned O&G infrastructure off Thevenard Island as well as the EIAR which was constructed using repurposed O&G infrastructure and purpose-built structures. The benefit transfer approach found increased use values (expenditures and consumer surplus) for recreational fishers at these sites. The precise value highly depended on the fish biomass present, and therefore the catchability on these structures. The random utility model indicated that the Thevenard O&G infrastructures could potentially increase the welfare of both recreational fishers and divers significantly, depending on who was granted access to the structures. The EIAR on the other hand had a significantly positive effect on the site choice of recreational fishers, but not divers.

The importance of rigs-to-reefs providing increased fish biomass was also measured by the discrete choice experiment on preferences of the general public in WA. We found that other attributes of an improved environment such as the provision of habitat for threatened species or the production (rather than the attraction) of fishes was preferred. Moreover, the study showed that WA's community preferred reefs with increased revenue for the State budget or access for divers. However, preferences for rigs-to-reefs were reduced if liability lay with the Government, or the social licence to operate granted to the O&G sector was low.

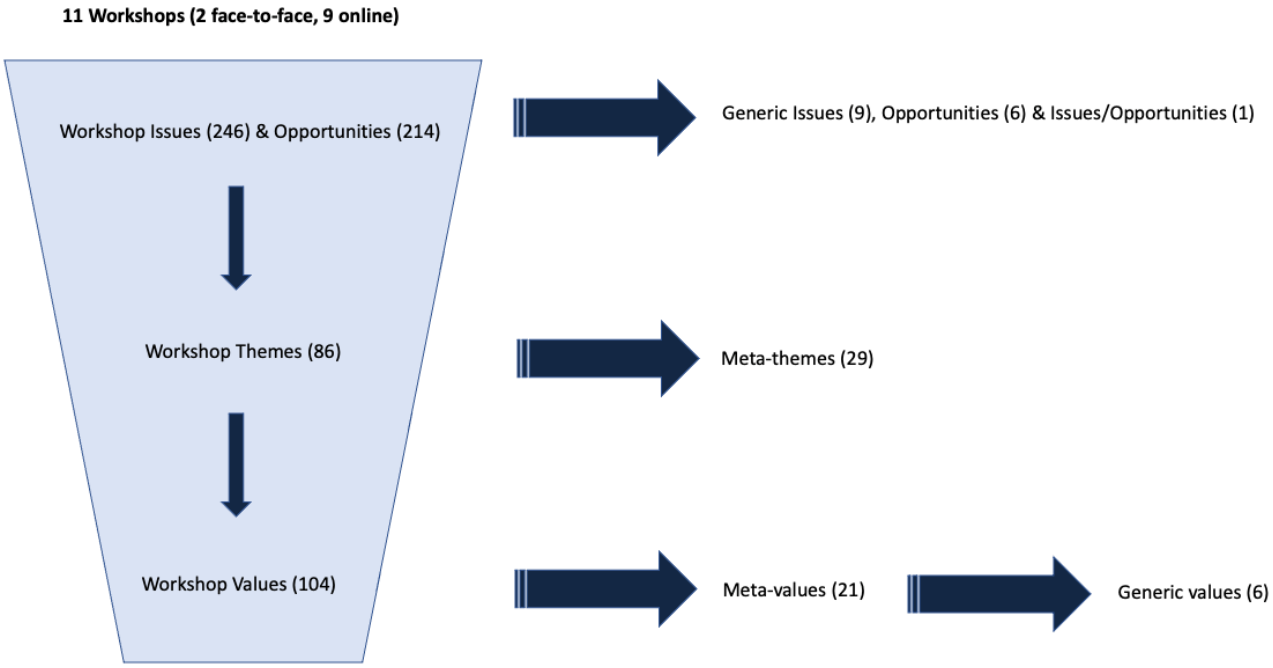
The estimates of the value per day of a diving trip in the Exmouth region was substantially higher than that for a trip to Busselton Jetty, which in turn was higher than estimates for fishing trips to MMS in Geographe Bay. This can largely be explained by the degree to which there are substitute activities for the MMS: not only the presence of MMS but the quality of the experience that they gave. For those using Busselton Jetty, the majority of whom did not fish or dive, there were few experiences that were similar, and even for fishers, who one could argue can access numerous other fishing points, there were few that can give such access without a boat. The MMS in Geographe Bay had a large number of natural substitute sites.

Results: Social value - group

This section presents the results of the Social Values Group component of the research/project. We discuss the synthesis process adopted, before presenting the data. Commencing with the findings relating to values (attending to their systemic impacts, propensity, and convergence with the literature derived framework), the themes (the breadth, their relationship to the values, and associated priorities), opportunities and threats (which are dominant, support for the values etc.) we then present the Busselton case study and the resultant information. Finally, we consider the integration of these different data categories before concluding with a discussion of the integration of the social value group and individual values, opportunities, and issues.

Given the focus on eliciting deep and systemic data, the analysis process focused initially on exploring the three categories: values, emergent themes, and issues/opportunities in terms of their depth (amount of material supporting them), frequency (how often they emerged in the focus groups) and systemic disposition (their position in the network etc.). As such each 'strata' (see Figure 31 below) is analysed (a horizontal assessment) followed by a systemic integrated and vertical assessment. The results are provided below.

Figure 31: illustration showing the three levels of data, and the synthesis process.



An overarching examination (comprising all three categories) was conducted to exploit the systemic nature of the data and gain a set of holistic insights/findings. As such, each value was considered in conjunction with the material supporting it, and each opportunity/issue could be scrutinised to determine which value(s) it impacted. This provides a more nuanced appreciation and potentially better outcomes. For example, based on the combination of analysis and the resultant findings, decision makers will be able to determine how much variance there is between the value systems of different cohorts, where there is agreement and where there is difference between values; which of the values is founded upon a predominance of issues (suggesting it is a value of concern) and which of the values is supported by a predominance of opportunities (implying an aspiration). Consequently, decision makers will be in the position of being well informed regarding what substantiates each of the values (comprising a mix of opportunities and issues), and where there are possible tensions between issues and opportunities and between stakeholder groups. Therefore, the analysis and subsequent findings provide decision makers with a number of models to inform robust decision making (objective 1). Through the generation of a range of models the analysis and findings also provides a framework against which policies and actions can be

considered (objective 4). In addition, an in depth/targeted examination of the Busselton community (objective 3) allows for a micro exploration of the impact of MMS on a particular geographical location.

The 11 focus groups gave rise to 104 values, 86 themes, 246 issues and 214 opportunities (Table 26).

Table 26: Values, themes, issues and opportunities derived from focus groups.

Workshop	Issues	Opportunities	Issues/Opportunities	Themes	Values
Exmouth 1	9	13	0	10	21
Exmouth 2	21	21	0	12	10
Chevron	16	21	1	10	5
Regulator 1	16	21	6	6	8
Oil & Gas	26	15	1	5	12
Regulator 2	29	15	4	6	7
Recreational Fishers	32	38	6	8	15
Karratha & Onslow	13	20	6	6	5
Busselton	23	19	1	8	5
Commercial Fishers	32	14	2	7	5
Non-Government Organisation	29	17	1	8	11

Values

As noted in the methods, 11 focus group workshops were carried out giving rise to 104 values revealing the breadth of potential values. This ties in with the literature where it is argued that it is important to recognise "the plurality of stakeholders and result in competing strategies and goals" (Smith and Lewis, 2011, p384). In each workshop the values were seen as a system, i.e. values could support values with the values at the top of the chain being very broad and those further down being more detailed. For example, it is worth noting that *protecting/enhancing the marine environment* emerged as an overarching value at the top of the chain. When exploring each workshop's value systems, there was considerable homogeneity in both the values and their relationships. Many of the values were similar in content/meaning and were able to be combined into 21 meta-values - synthesising the value material. From the exploration of the breadth and interconnectivity of the values a number of models were able to be produced.

Building a decision tree: A key part of multi-criteria model building

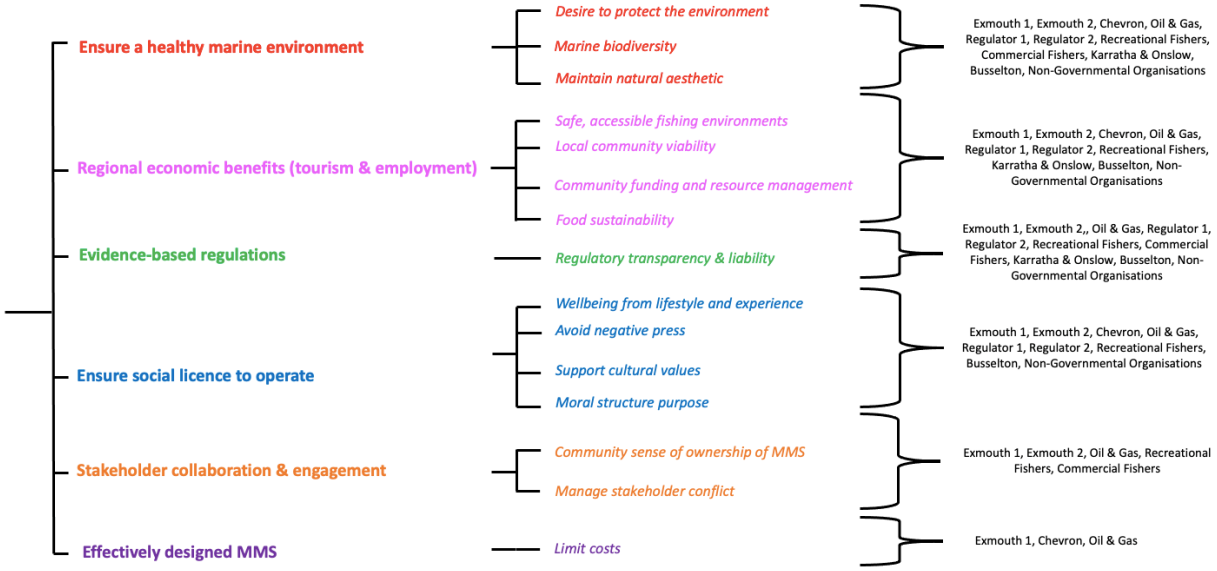
The meta-values, along with the relationships between them (retaining the systemic property) were used to produce a decision tree. Decision trees can be used to aid decision makers when considering a range of options as they provide the criteria against which each option can be assessed once weights are allocated to the criteria/values (for example each criteria could be given equal weighting or criteria could be given differential weights depending on the decision maker – either way the weighting would be made explicit).

The tree below (Figure 32) reflects the values and highlights that there are 6 generic values/criteria supporting the 21 meta-values.

1) Ensure a healthy marine environment.
2) Regional economic benefits.
3) Evidence based regulations.
4) Ensure social licence to operate.
5) Stakeholder collaboration and engagement.
6) Effectively designed MMS.

Each of these generic criteria have sub-criteria reflecting the meta-values. For each of the generic values (and associated meta-values) the range of the stakeholder workshops is noted illustrating that in four of the six 'branches' a number of the stakeholder cohorts supported the value (the least supported generic value focusing on design considerations and predominantly supported by O&G).

Figure 32: Values decision tree organised by generic values, meta-values values and contributing workshops.



The decision tree provides decision makers with the basis upon which to construct a multi-criteria decision model. Each of the meta-values would have to be allocated a weighting as would the generic values before the model could be used to assess different options (which are scored against the weights). This could be carried out with particular stakeholder cohorts and informed by the prioritisation process conducted against the themes. In addition, it would be possible to customise the tree, focusing on the generic/meta values that were of particular interest to the stakeholder group/context.

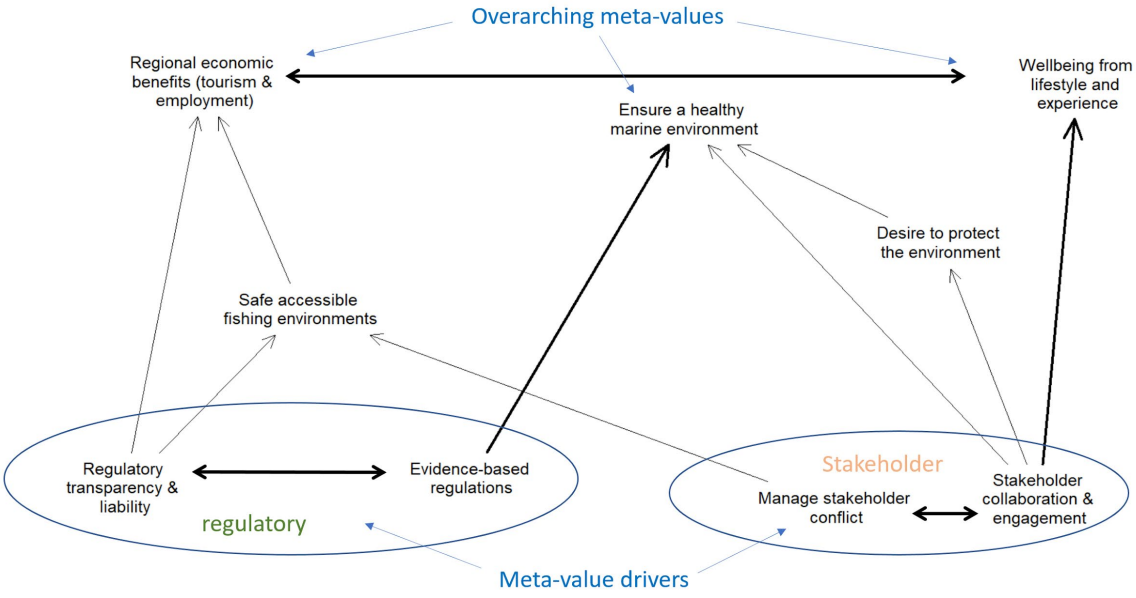
Understanding the value systems

As noted earlier, workshop values were not discrete, i.e., some values were supported, or were supported/reinforced by other values. This information is important as it provides a more nuanced appreciation of the social value landscape and provides the opportunity for greater impact.

Complementing the decision tree, and providing an alternative representation, a values map was produced. The map aids with facilitating an *understanding* of both centrality and frequency/ownership of each meta-value (objective 1). For example, '*ensure a healthy marine environment'* (a value owned by all workshops) has a central position in the system as did '*regional economic benefits*' (see Figure 33 below). The meta-values are linked using arrows based on how the workshop values were linked. If the links between meta-values were demonstrated in two workshops the connecting arrow is thicker and where the values supported one another a double headed arrow is presented showing dynamic self-reinforcing behaviour. Three superordinate values are noted (overarching values) and three supporting values (drivers) presented.

Attending to the driver values would have a positive impact on the other values. The below Figure (33) shows a high-level view – comprising those values that were elicited from 6 or more of the focus group workshops and so the mostly widely held. The full values system can be found in Appendix 10.

Figure 33: Meta-values map reflecting the values that had the greatest elaboration in terms of cohort oriented themes (6 or more).

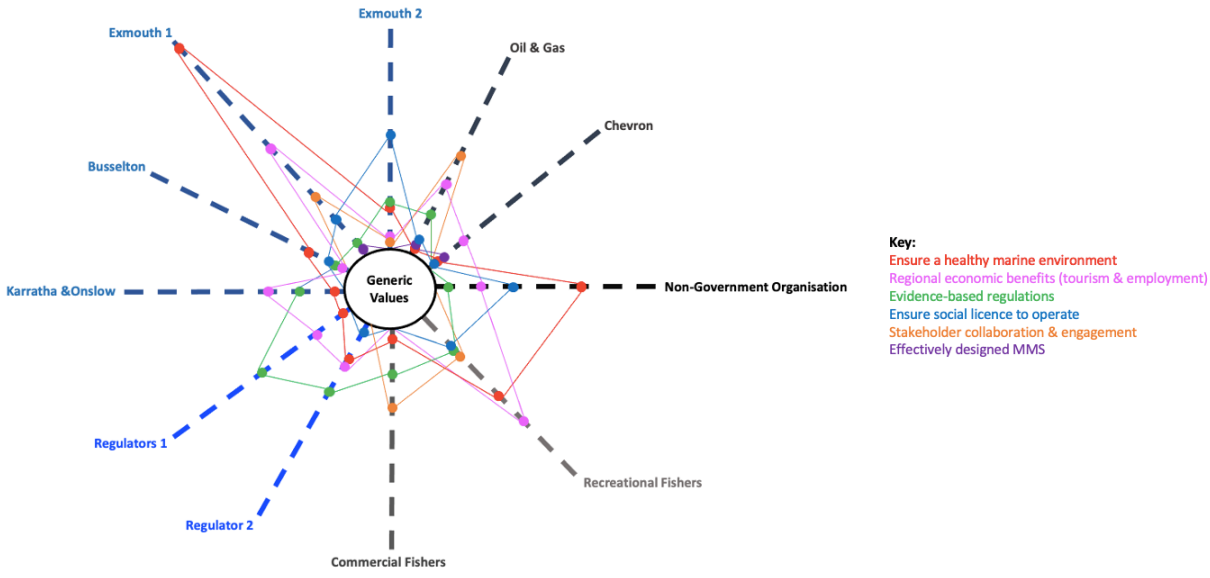


Note: those values at the bottom of the figure support those at the top – for example regulatory transparency may support ensuring safe accessible fishing environments and may support regional economic benefits.

Spider (or radar) graphs

Using the generic values and focus group data, it was also possible to construct spider graphs to illustrate the difference emphases between cohorts. Spider graphs (e.g. Figure 34) are one way of visualising data, and are used to plot one or more groups of values over multiple common variables represented on axes starting from the same point. This provides an alternative means of viewing the ownership of the values and a sense of the range of values generated during the focus group workshops.

Figure 34: Generic values spider graph.



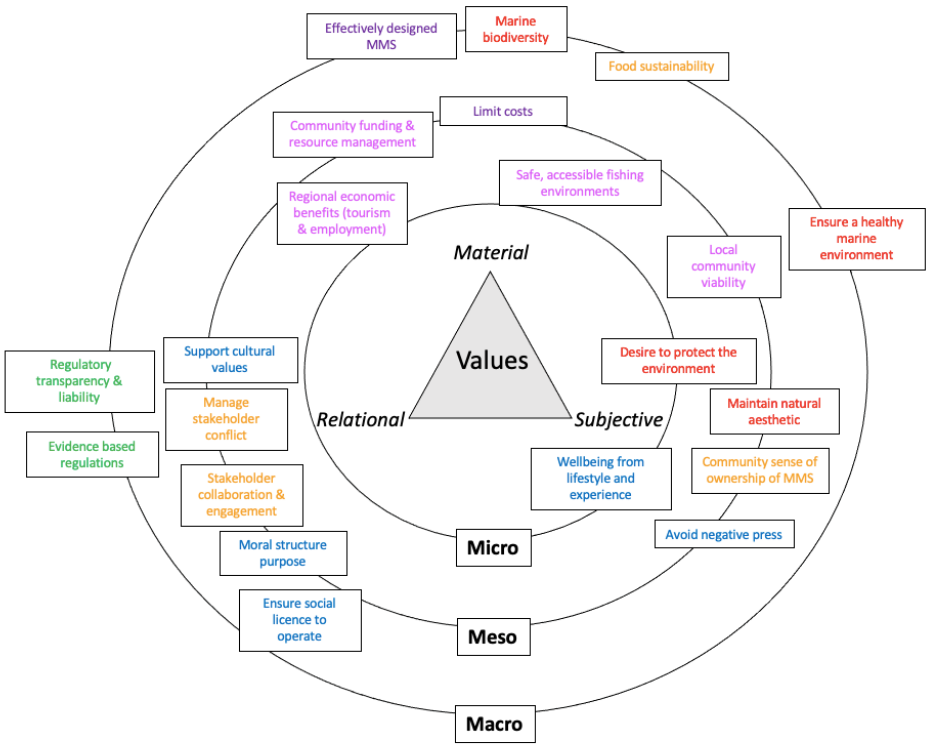
Note: The spider graph displays the number of values each individual workshop contributed to generic values. Workshop values were grouped into meta values and these meta values contribute to the generic values that are labelled in the centre of the spider plot. Location of the position (coloured circles) was determined based on how much material each individual workshop contributed to the generic value. Each dash on a line represents the amount of contributing material from 1 – 7.

From the above spider graph, it can be seen that there are differences in support for each of the generic values. For example, the generic value related to '*healthy marine environment'* appears on all of the axes, however it barely registers on some and dominates others gives a sense of appetite/support for the value. The graph therefore presents an easily viewable image of the heterogeneity of each stakeholder group. Individual spider graphs for each generic value can be found in Appendix 8.

Mapping values to the literature framework

A final activity was to map the meta-values on to the literature framework (Weeratunga et al, 2014). As such it was possible to determine if each of the three dimensions were supported, whether the different levels (i.e. macro, micro and meso) were supported and whether the generic values were situated in specific sectors of the framework. The resultant plot (Figure 35) demonstrates all three literature-based values were supported, and all three levels of analysis were supported. In addition, it revealed that there were distinct clustering's i.e. meta-values relating to regulatory matters were solely situated in the relational arena whereas those related to collaboration and engagement appeared in all three.

Figure 35: Plot of workshop social values onto Weeratunga et al (2014) framework.



Key: Ensure a healthy marine environment, Evidence-based regulations, Regional economic benefits (tourism & employment), Stakeholder collaboration & engagement, Effectively designed MMS, Ensure social license to operate

Overall, the figure illustrates that material values are dominated by the regional economic benefits and effectively designed MMS, whereas relational values see stakeholder collaboration and engagement, social licence and regulatory considerations. The marine environment predominantly sits in the subjective sector.

In reviewing the values, the analyses illustrate that there exists a wide range of values, that the values can be distilled into six generic values, or if a more fine-grained approach is required, a set of 21 meta values. The meta value level provides more nuanced appreciation necessary for decision making. In addition,

different stakeholder groups/cohorts have different appetites for the values. Thus, there are some values that are strongly subscribed to by all, and other values that have only partial (or lukewarm) support. Finally, the analyses reveal the systemic nature of values highlighting the importance of taking a holistic approach when determining policy and action.

Themes

As noted in the methods section, each workshop gave rise to a series of 'clusters' of material - themes - comprising the issues, opportunities and their interconnections. The 11 workshops yielded 86 themes in total, with each workshop generating between five to 12 themes. The themes were reviewed individually with each workshop cohort to check for comprehension and ensure that the material within them was appropriately situated. As with the values, the themes were reviewed for similarity and able to be distilled into 29 meta-themes (Table 27).

Table 27: Listing the generic values and meta-themes that support them.

Generic Value	Contributing Meta-Theme
Ensure a healthy marine environment	• Location of MMS • Increase habitat productivity • Spread pressure across reef systems • Increase community awareness of marine environment • Competing stakeholder values • Pollution from MMS • Detrimental impact to the marine environment • Research opportunities • Ensure sustainable fishing activity • Reduce regulation uncertainty • Plan for future decommissioning • Managing multi-user risk • Environmental stewardship • Understand MMS structure
Regional economic benefits (tourism & employment)	• Location of MMS • Increase habitat productivity • Increase community awareness of marine environment • Competing stakeholder values • Liability and responsibility of MMS • Pollution from MMS • Detrimental impact to the marine environment • Employment opportunities • Impact on local infrastructure • Safety hazard from MMS • Cumulative impacts of multiple structures • Understand and achieve environmental, social and economic outcomes • Managing multi-user risk • Environmental stewardship • Increase stakeholder collaboration • Financial assessment and management of MMS • Understand MMS structure • Increased tourism
Evidence-based regulations	• Liability and responsibility of MMS • Pollution from MMS • Detrimental impact to the marine environment • Research opportunities • Policy unable to keep up with sector

	• Reduce overall decommissioning cost • Understand economic lifecycle cost-benefit analysis • Understand and achieve environmental, social and economic outcomes • Reduce regulation uncertainty • Plan for future decommissioning • Managing multi-user risk
Ensure social licence to operate	• Location of MMS • Increase habitat productivity • Increase community awareness of marine environment • Competing stakeholder values • Liability and responsibility of MMS • Pollution from MMS • Detrimental impact to the marine environment • Research opportunities • Policy unable to keep up with sector • Understand and achieve environmental, social and economic outcomes • Managing multi-user risk • Environmental stewardship • Increase stakeholder collaboration
Stakeholder collaboration & engagement	• Location of MMS • Increase habitat productivity • Spread pressure across reef systems • Increase community awareness of marine environment • Competing stakeholder values • Research opportunities • Policy unable to keep up with sector • Current data gaps • Cumulative impacts of multiple structures • Balancing risk – leave in vs removal • Reduce regulation uncertainty • Increase stakeholder collaboration • Understand MMS structure
Effectively designed MMS	• Location of MMS • Increase habitat productivity • Liability and responsibility of MMS • Pollution from MMS • Research opportunities

Note: Meta-themes can support >1 generic value.

Reviewing the meta themes, 14 supported both healthy marine environment, 18 supported regional economic benefits and 11 supported evidence-based regulations, 13 Ensure social licence to operate, 13 Stakeholder collaboration & engagement and 5 Effectively designed MMS. From this it could be concluded that values around ensuring regional economic benefits was first and foremost in participant minds.

Four of the meta themes supported 5 generic values namely, location, marine productivity, pollution, and research, and five supported four generic values namely: community awareness, competing stakeholder values, liability concerns, detrimental risk and multi-user risk. One possible insight from this is that these meta themes were seen as *potent* (providing considerable leverage) in terms of addressing the generic values, and thus exploring the issues and opportunities supporting them would give decision makers useful information when considering policies and action.
As noted in the methods, once the themes had been reviewed, and the opportunities and issues structured using the causal mapping process participants were asked to rate the themes - allowing for some prioritisation to be revealed. The process allows for both the identification of preference (the highest

average) and the degree of consensus (the lower the score the greater the degree of consensus). Table 28 shows the results of the prioritisation process with each meta theme being listed alongside the contributing workshop cohort.

Table 28: Meta-themes by cohort workshops.

Meta-theme	Contributing Workshops (number of attendees)	Average Rating of Importance (out of 10) & Range	Degree of Consensus & Range
Reduce overall decommissioning cost	Chevron (4)	8.3	1.9
Environmental stewardship	Regulator 2 (8) Recreational Fishers (6)	7.95 (6.5 - 9.4) Regulator (9.4) Recreational Fishers (6.5)	1.2 (0.86 - 1.5) Regulator (0.86) Recreational Fishers (6.9)
Current data gaps	Oil & Gas (5)	7.6	1.4
Understand MMS structures	**Recreational Fishers (6)** Karratha & Onslow (4) **Commercial Fishers (7)** NGO (7)	7.5 (5.5 - 9.5) Recreational Fishers (9.5) Karratha & Onslow (7.5) NGO (5.5)	1.6 (0.87 - 2.4) Recreational Fishers (0.87) Karratha & Onslow (1.5) NGO (2.4)
Reduce regulation uncertainty	**Regulator 1(4)** **Regulator 2 (8)** Recreational Fishers (6)	7.5 (6.3 - 8.3) Regulator 1 (8.3) Regulator 2 (8) Recreational Fishers (6.3)	1.7 (0.83 - 2.9) Regulator 1 (0.83) Regulator 2 (1.7) Recreational Fishers (2.9)
Research opportunities	**Exmouth 1 (7)** **Exmouth 2 (8)** Regulator 1 (4) Recreational Fishers (6)	7.3 (6.3 - 8.3) Regulator 1 (8.3) Recreational Fishers (6.3)	1.7 (1.5 - 1.8) Regulator 1 (1.5) Recreational Fishers (1.8)
Managing multi-user risk	Regulator 1 (4) Karratha & Onslow (4)	7.25 (6.5 - 8) Karratha & Onslow (8) Regulator 1 (6.5)	2.2 (2.1 - 2.3) Regulator 1 (2.1) Karratha & Onslow (2.3)
Increase stakeholder collaboration	Regulator 2 (8) Recreational Fishers (6)	7.2 (6.4 - 8) Recreational Fishers (8) Regulator 1 (6.4)	2.2 (1.9 - 2.5) Recreational Fishers (1.9) Regulator 1 (2.5)
Understand and achieve environmental, social and economic outcomes	Regulator 2 (8) **Recreational Fishers (6)** **Karratha & Onslow (4)** **Busselton (4)** **Commercial Fishers (7)** NGO (7)	6.75 (5 - 8.6) Regulator 2 (8.6) Recreational Fishers (7.8) Karratha & Onslow (5.3) Busselton (5)	2.4 (0.83 - 6.3) Recreational Fishers (0.83) Busselton (1.4) Regulator 2 (1.9) Karratha & Onslow (6.3)
Increased tourism	**Exmouth 2 (8)** **Karratha & Onslow (4)** NGO (7)	6.6 (5 - 8.3) NGO (8.3) Karratha & Onslow (5)	1.44 (10.97 - 1.9)
Location of MMS	**Exmouth 1 (7)** **Karratha & Onslow (4)** Commercial Fishers (7)	6.5	1.5

Understand economic lifecycle cost-benefit of MMS	Chevron (4)	6.5	2.5
Cumulative impacts of multiple structures	Oil & Gas (5)	6.4	3.1
Policy unable to keep up with sector	Chevron (4) Busselton (4) Commercial Fishers (7)	6.2 (6 - 6.3) Chevron (6.3) Busselton (6)	1.7 (1.5 - 1.9) Chevron (1.5) Busselton (1.9)
Pollution from MMS	**Exmouth 1 (7)** **Exmouth 2 (8)** Chevron (4) Regulator 1 (4)	6.2 (5.5 - 6.8) Regulator 1 (6.8) Chevron (5.5)	1.7 (1.6 - 1.8) Regulator 1 (1.6) Chevron (1.8)
Detrimental impact to natural environment	**Exmouth 1 (7)** **Exmouth 2 (8)** Regulator 1 (4) **Busselton (4)** NGO (7) Chevron (4)	6.2 (3.3 - 8.7) NGO (8.7) Regulator 1 (6.8) Busselton (6.5) Chevron (3.3)	2.1 (1.6 - 2.6) Regulator 1 (1.6) Chevron (1.8) Busselton (2.5) NGO (2.6)
Liability and responsibility of MMS	**Exmouth 1 (7)** **Exmouth 2 (8)** **Chevron (4)** **Oil & Gas (5)** **Karratha & Onslow (4)** **Busselton (4)** Commercial Fishers (7) NGO (7)	5.9 (4.3 - 9) Chevron (9) Karratha & Onslow (5.8) Busselton (5.8) Oil & Gas (4.6) NGO (4.3)	2 (0.71 - 3.1) Chevron (0.71) NGO (1.1) Karratha & Onslow (2.2) Busselton (2.9) Oil & Gas (3.1)
Increased habitat productivity	**Exmouth 1 (7)** **Exmouth 2 (8)** **Chevron (4)** **Oil & Gas (5)** Regulator 2 (8) **Busselton (4)** Commercial Fishers (7)	5.9 (5.5 - 6.5) Busselton (6.5) Chevron (5.8) Oil & Gas (5.8) Regulator 2 (5.5)	2.25 (1.5 - 2.7) Busselton (1.5) Regulator 2 (2.2) Chevron (2.5) Oil & Gas (2.7)
Safety hazards from MMS	**Exmouth 2** Chevron (4) **Busselton (4)** NGO (7)	5.5 (4.3 - 7) Busselton (7) NGO (5.2) Chevron (4.3)	2.5 (2.1 - 2.8) Busselton (2.1) NGO (2.5) Chevron (2.8)
Increased community awareness of marine environment	**Exmouth 1 (7)** **Exmouth 2 (8)** **Busselton (4)**	5.5	2.7
Competing stakeholder values	**Exmouth 1 (7)** **Chevron (4)** **Oil & Gas (5)** **Busselton (4)** NGO (7)	5.4 (3 - 8.8) Busselton (8.8) Oil & Gas (6.4) Chevron (3.5) NGO (3)	2.2 (1.1 - 3.3) Busselton (1.1) NGO (3) Oil & Gas (3.1) Chevron (3.3)
Financial assessment and management of MMS	Recreational Fishers (6)	5	3.2
Balancing risk - leaving in vs. removal	Oil & Gas (5) NGO (7)	4.6 (3 - 6.2) NGO (6.2) Oil & Gas (3)	2.5 (2.4 - 2.5) Oil & Gas (2.4) NGO (2.5)
Ensuring sustainable fishing activity	Chevron (4)	3	0.71
Spread pressure across reef systems	Exmouth 1 (7)	N/A	N/A

Employment opportunities	Exmouth 1 (7)	N/A	N/A
Impact on local infrastructure	Exmouth 2 (8)	N/A	N/A

Note: Workshops themes were collated into meta-themes displayed in column one. Meta-themes are colour coded based on which generic theme they contributed to (Ensure a healthy marine environment, Evidence-based regulations, Regional economic benefits (tourism & employment), Stakeholder collaboration & engagement, Effectively designed MMS, Ensure social license to operate). In column two workshops that contributed to these meta-themes (e.g., had at least one workshop theme that contributed to the meta-theme) were listed. If a meta-theme is contributed to in two or more category of workshop (e.g., community, fishers, regulators, O&G) the names of those workshops are noted in bold font. Average importance ratings and degree of consensus ratings were taken in eight of the 11 workshops. Importance rating and degree of consensus does not include Exmouth workshops (different rating system because of face-to-face workshop) or commercial workshop (rating not used during this workshop). These ratings for workshop themes were averaged together depending on which meta-theme it contributed to. The ranges of these ratings were also reported. In some cases, a meta-theme was only contributed to by one workshop and a range was not possible to report.

When reviewing Table 28, it can be seen that for a number of meta-themes there was a range of views regarding importance.

- The meta-theme with the highest average was *decrease overall decommissioning costs*, however it is worth noting that this only appeared in one workshop.
- Understanding MMS structures (which reflected an interest in more research) appeared in four of the workshops and received the fourth highest overall average. However, there was quite a range as one workshop averaged 5.5 with another averaging 9.5 suggesting a high degree of variability in terms of preference. There was also a degree of difference in terms of the intra-workshop rating with only a medium level degree of consensus.
- The meta-theme relating to *understand and achieve economic, social and environmental outcomes* was rated the most often.
- The meta theme relating to research was identified regularly, was prioritised by four cohorts and was seen as important by many. However, on closer look this apparent homogeneity is reduced as the forms and foci regarding research are quite different.

When exploring the similarity/differences across stakeholder workshops it was interesting to note:

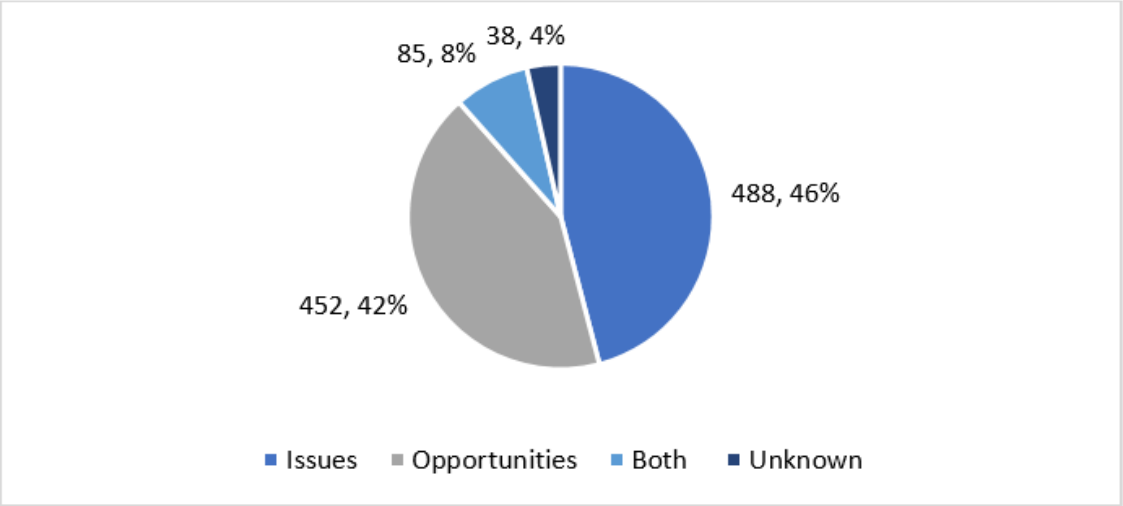
- Meta-themes shared across recreational and commercial fishers' workshops included *understand and achieve environmental, social and economic outcomes* and *understand MMS structures (which had a research connotation)*.
- The only meta-theme shared across community workshops (Karratha & Onslow, Busselton, and Exmouth 1 & 2) related to *liability and responsibility of MMS*.
- There were no shared meta-themes across all of the regulator, NGO and oil & gas workshops.

Overall, the themes and meta-themes provide insights into the 'bundles' of issues and opportunities surfaced during the workshops. In addition, the range of meta-themes gives insight into the extensiveness of concerns and hopes illustrating the diversity of view. In some workshops the themes giving rise to the meta-themes were well developed comprising 10 or more issues/opportunities, however in other instances they were much sparser only comprising three or four issues/opportunities. When reviewing the prioritisation process in some instances there was high levels of agreement e.g. '*increased habitat productivity* whereas in others the priorities were quite different e.g. *liability and responsibility of MMS'*. This meta-theme had a range of averages from 9/10 (Chevron) to 4.3 (O&G & NGO).

Opportunities and issues

An assessment was carried out on the issues and opportunities. The first analysis centred on the balance of issues to opportunities. This was found to be fairly even with issues comprising around 46% of the material generated, and opportunities making up 42%. In some instances, participants view the contribution as potentially being both (8%) and in a few occasions didn't register whether the statement was an issue or opportunity (4%).

Figure 36: Issues and opportunities.



Note: Issues and opportunities sometimes contributed to more than one workshop theme. An I/O/B was deemed as contributing to a workshop theme if it was linked to the theme via an ingoing arrow. This chart demonstrates how the contribution of issues and opportunities was distributed between the 86 workshop themes.

A further analysis explored the complexion of the meta-themes, i.e. whether they were evenly balanced in terms of issues/opportunities or not (see appendix 11 for 'Issues and opportunities underpinning the meta and generic values'). The analysis also explored the range of issues/opportunities supporting the meta-themes. Table 29 notes each meta-theme, the number of issues/opportunities/both associated with them. Insights from this include:

- those meta-themes that were dominated by a wide range of issues e.g. '*competing stakeholder values', 'liability and responsibility of the MMS', 'detrimental to the natural environment'* and *'reduce regulatory uncertainty'*. There were also meta-themes that were predominantly issue oriented but without such depth of material.
- those meta-themes that were dominated by a wide range of opportunities e.g. '*increased habitat productivity*', and '*understand and achieve environmental, social and economic outcomes*'. As with the issue dominated meta-themes, there were a few that were broadly opportunities but did not have a substantial amount of material supporting them.
- those meta-themes that were extensively supported.

Table 29: Issues and opportunities contributing to meta-themes.

Dominant Issue	Contributing Stakeholder Cohorts
Balance access across stakeholders	**Community**, Oil & Gas, Fishers
Risk of fish stock depletion	**Community,** Oil & Gas, Regulator, Fishers, NGO
Creation of user/navigational hazards	**Community,** Oil & Gas, **Regulator,** Fishers, NGO
Disintegration of structure	**Community,** Oil & Gas, Regulator
Spread of invasive species	Community, Oil & Gas, Regulator, NGO
Lack of clarity around ownership/liability	Community, **Oil & Gas, Regulator,** Fishers, NGO
Perception of 'dumping'	Community, **Oil & Gas, Regulator,** Fishers, NGO
Changes to natural aesthetic	**Community,** Oil & Gas, NGO
Impact on natural environment	**Community,** Oil & Gas, **Regulator,** NGO
Dominant Opportunity	**Contributing Workshops**
Increased fish habitat	**Community,** Oil & Gas, Fishers, NGO
Recycling material	**Community,** Oil & Gas, **Regulator**
Increase tourism	**Community, Oil & Gas,** Regulator, NGO
Provides recreational uses	**Community,** Oil & Gas, Regulator NGO
Ensuring economic gains	**Community,** Oil & Gas, Fishers, NGO
Job creation	**Community,** Oil & Gas, **Regulator,** Fishers
Dominant Issues/Opportunity	**Contributing Workshops**
Undertaking (further) research	**Community, Regulator,** NGO

Note: Dominant issues (I) and opportunities (O) were determined after compiling lists of Is, Os, and both issues and opportunities (B) for each of the 11 workshops. Each I, O and B list was examined for common words/themes/meanings to create a dominant set. Workshop themes were excluded from this process as they are a summary of the current data being examined. I, O, and Bs are considered dominant if they are addressed by at least 3/4/5 workshops.

Overall, when considering the balance between issues and opportunities there is a fairly even spread. However, a deeper scrutiny reveals that some of the meta themes were dominated by issues or opportunities. For example, the meta-themes below are dominated by issues,

- Liability and responsibility (47).
- Detrimental impact to the natural environment (58).
- safety hazard (26).

Whereas only one theme was dominated by opportunities

- increased community awareness of marine environment (29).
-

Returning to the issue of balance, 4 meta-themes received high volumes of both issues and outcomes,

- competing stakeholder values (53) (29).
- reduce regulatory uncertainty (44) (35).
- increased habitat productivity (36) (54).
- understand and achieve environmental, social and economic outcomes (34) (71).

The meta-themes can be clustered together, e.g. liability and responsibility and reduce regulatory uncertainty making up one cluster, detrimental impact to the natural environment and increased habitat productivity making up another.

Busselton case study

The Busselton focus group took place on the 14th July 2020 and involved 4 participants from a range of different organisations and disciplines. It followed the same design as all of the other focus groups and was conducted on-line. Despite the small number of participants, the group was able to construct a model comprising 76 statements (issues, opportunities, values). Analysis of the resultant model gave rise to the following observations.

When reviewing the themes, the theme titled 'manage the type and use of MMS was prioritised most frequently, receiving a score of 8.8/10 with a high degree of consensus. The theme reflected the recurring theme relating to potential competing demands amongst stakeholders and was a mix of both issues and opportunities. As in other workshops, another important theme for the group was habitat rehabilitation, closely linked to a theme comprising 'threaten the natural marine and coastal environment (particularly instigated by concerns regarding the theme of user safety). To a lesser extent there were concerns regarding liability and cost and an appreciation of the economic benefits for the area. A final theme, that was relatively distinct to the group centred on understanding of the natural environment.

Busselton contributed to 4/6 generic values (Ensure a healthy marine environment, Regional economic benefits, Evidence based regulations and Social licence to operate. In terms of the themes Busselton contributed to eight of the 29 generic themes and 4/9 of the dominant issues 2/6 opportunities. Thus demonstrating a high degree of similarity and shared many commonalities with the other community oriented workshops.

Along with having similarities with much of the material elicited, the group raised a relatively unique value - 'Australian Way of Life' and added a particular nuance to the social licence to operate through the value of 'inspire a younger generation about the marine environment.

Table 30: Statistics from Busselton workshop.

Participants	Values	Themes	Issues	Opportunities	Total
4	5	8	23	19	76

Summary: Holistic integrative analysis and participant engagement

In reviewing the focus group material together (rather than through the lens of particular data sets, e.g. values) four key content oriented aspects straddling all of the focus group workshops emerged. Each of these is discussed below. This is followed by process-oriented material reflecting the satisfaction/engagement with the process as noted by participants.

Regulatory environment

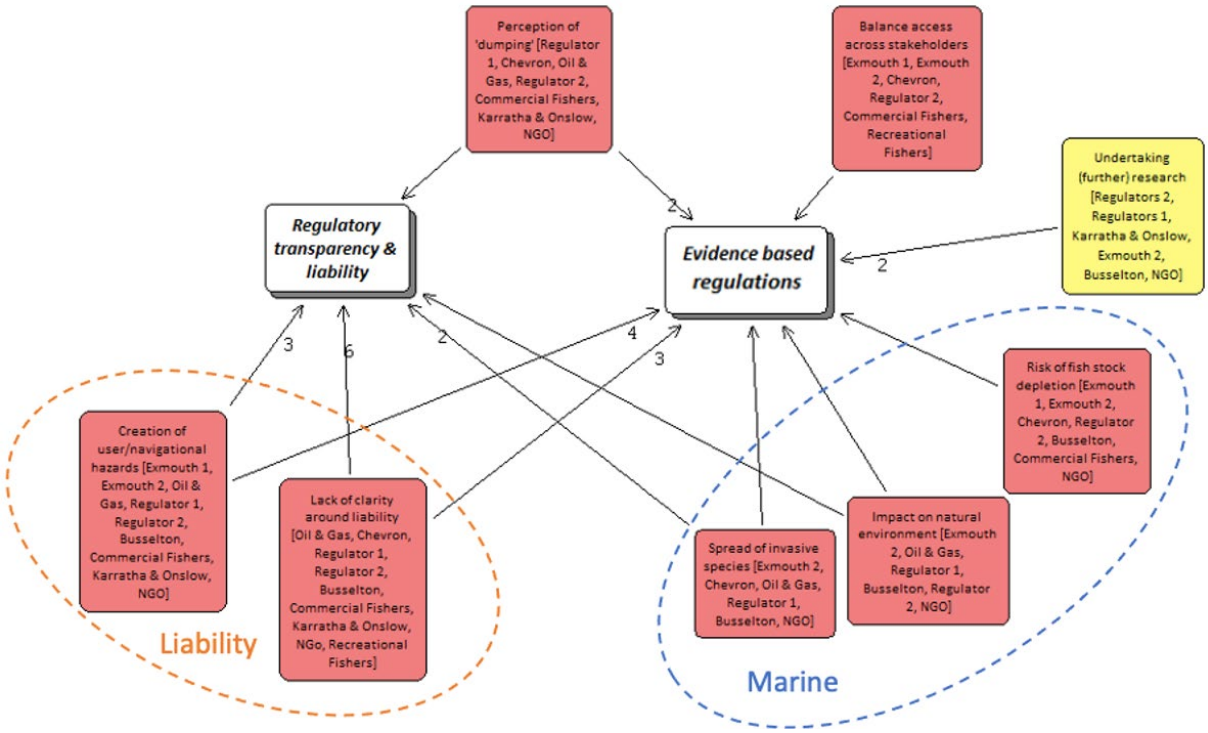
Legislation and regulation emerged consistently throughout the focus groups as an area of concern i.e., an issue. They comprised two connected values namely:

- ensure evidence-based regulations.
- ensure regulatory transparency and liability.

When reviewing these values alongside the issues and opportunities it is apparent that the two meta-values were dominated by issues. In the below figure (Figure 37), the two meta-values are positioned centrally (black text with borders). Linking into them are the dominant issues (red background). Each issue has listed the stakeholder groups that raised the issue (illustrating high degrees of homogeneity). Where there were multiple routes (links connecting an issue to a value, potentially through themes) these are noted at the arrowhead (for example, the issue relating to '*ownership and liability*' is linked six times to the value relating to *regulatory transparency*.

There appears to be two 'clusters' of 'dominant issues' namely marine and liability. These clusters reflect that a number of the issues are closely related. This key aspect is the only one that is extensively dominated by issues/concerns and therefore was one of great concern. In addition, many of the focus groups raised the need for 'additional research'. This is categorised as 'both' (yellow background) and constituted an opportunity (as it would facilitate action) and issue (there was insufficient data for effective decision making).

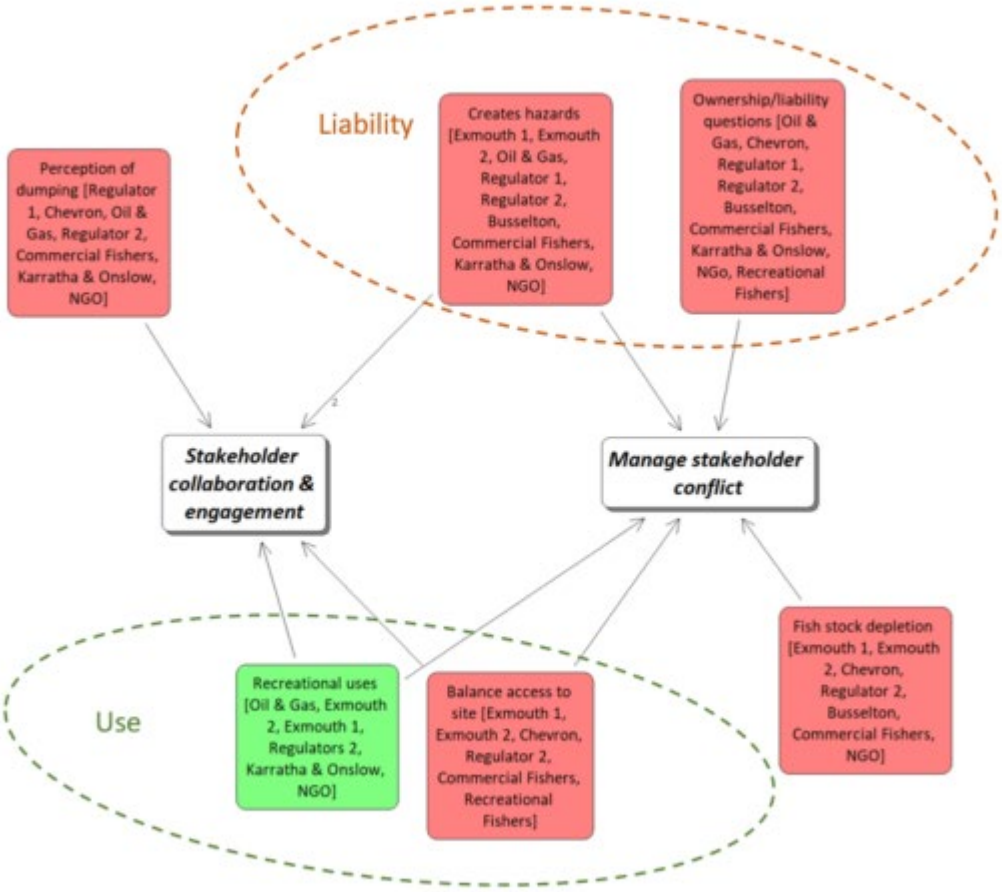
Figure 37: Regulatory aspect (meta-values) with associated dominant issues clustered.



Impact of stakeholder conflict versus collaboration and engagement

Effective engagement, collaboration, and the avoidance of conflict between stakeholders was another key aspect for many if not all of the workshop cohorts. As with regulatory considerations, two meta-values were central, namely *manage stakeholder conflict* and *stakeholder collaboration and engagement* (potentially reflecting two sides of the stakeholder coin) (Figure 38). It could be argued that these are the same in meaning if not in words, however it is worth considering whether the different terminology relates to the perceptions of the cohort members with some seeing conflict as a likely outcome (and thus taking a negative view) and others seeing real value in engaging stakeholders and as such potentially requiring different approaches. Interestingly, as with regulatory matters, the topic was supported by dominant issues with only one dominant opportunity. The two clusters of concern appear to relate to 'uses' and to 'liability' (linking it with the regulatory area) (Figure 38).

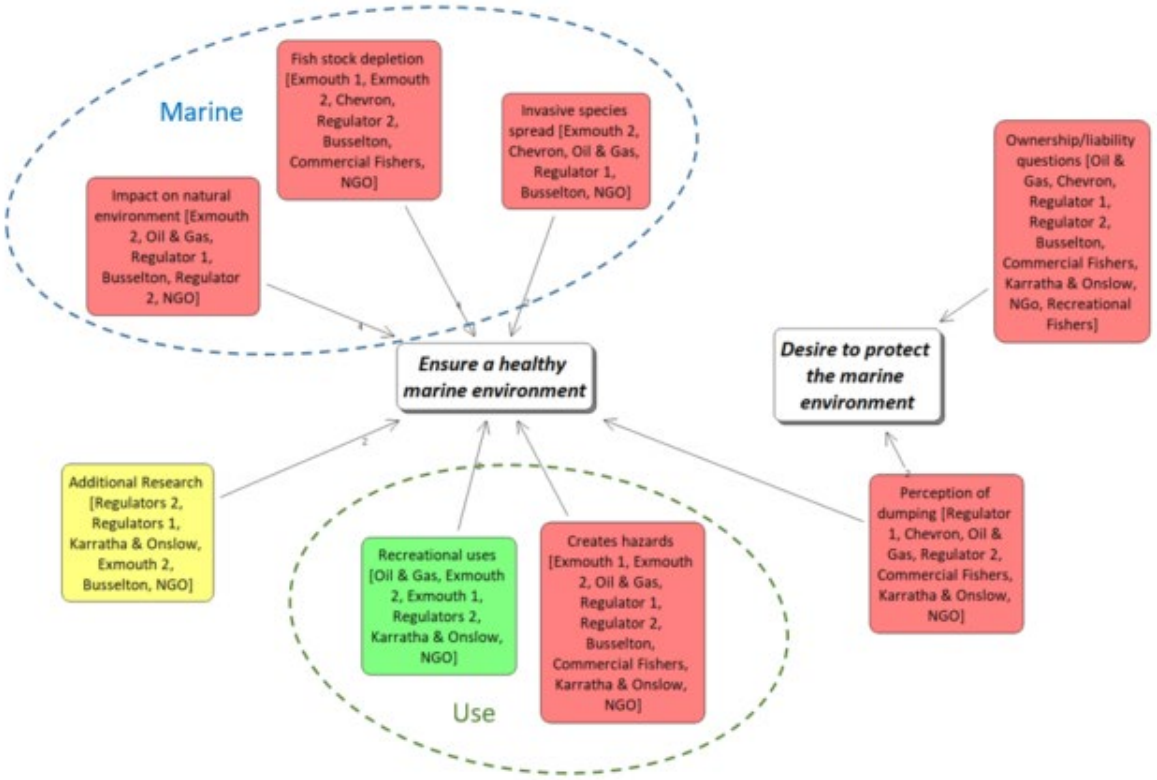
Figure 38: Stakeholder Aspect with associated clusters of issues and opportunities.



Retention/regeneration of a health marine environment

This aspect was not surprising - and comprised two meta-values namely *ensure a healthy marine environment* and *protect the marine environment* (Figure 39). Again, whilst these could be seen as synonyms the wording suggests different nuances - one focusing on protecting what is there currently, and the other potentially focusing on improvement. This separation is also reflected in the clusters of dominant issues and opportunities. For example, there is an issue dominated 'marine' theme, and a balanced 'use' theme (touching on the stakeholder aspect) relating to '*ensure a healthy marine environment*' as well as 'additional research'. *Desire to protect the marine environment* shares one of the dominant issues as well as being influenced by issues relating to liability (connecting it with the regulatory topic) (Figure 39).

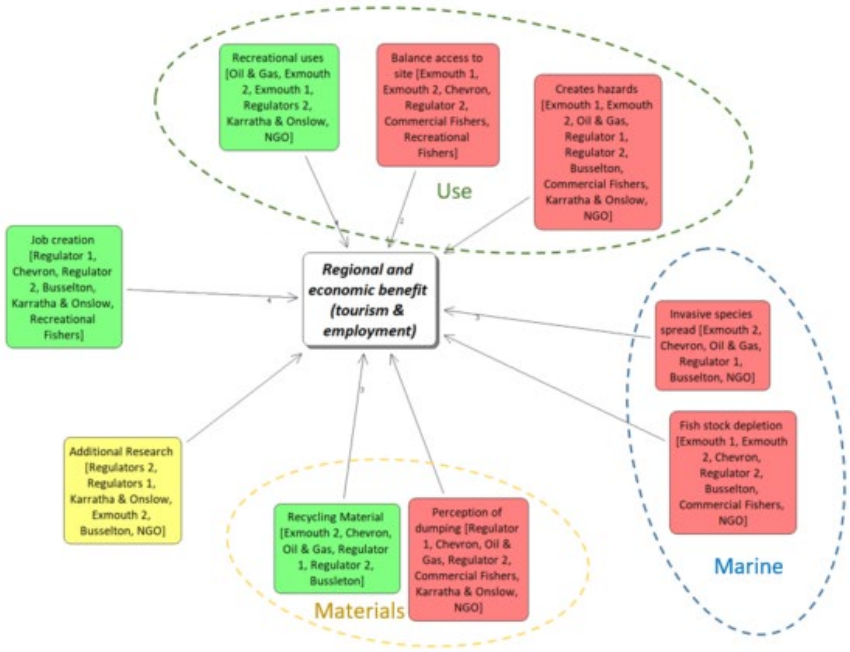
Figure 39: Marine environment aspect with associated clusters of issues and opportunities.



Regional benefits

The final aspect relates to regional and economic benefits and this topic sees a number of dominant opportunities supporting it (job creation, recycling and recreational uses) (Figure 40). However, there are still 5 dominant issues and the area of additional research. Use, materials and Marine emerge as the clusters of issues/opportunities.

Figure 40: Regional/economic benefit aspect with associated dominant issue/opportunity clusters.



Participant feedback

Alongside the data-oriented findings, there were also those relating to the processes adopted to elicit data reflecting participant involvement. Due to the impact of COVID-19, an alternative to face-to-face focus group workshops was required. One option was using a newly developed software package whereby participants could join the focus group from wherever they were using a standard web browser. The package allowed the issues, opportunities and values along with their impacts on one another to be modelled in the same manner as the face-to-face groups. However, given the newness of the approach feedback on the system, meeting process and facilitation of the group was sought to ensure the approach met the objectives.

The feedback was extremely positive across the nine sessions. Universally, participants noted how easy it was to use the system, that the process worked well, and that the facilitation was appropriate. Comments such as

"Using the strategy finder (the software) I think was really, really good because if I had just spent this much time of my day giving feedback without seeing it, how it all linked together and fed into another and helped inform my own mental map in live time. I may have thought it might be something I'm not too keen to do again but seeing it unfold in front of me and really understanding how it's been used is really, really helpful. And it feels like it was a good use of time. So, I want to thank you for engaging in that way" – Recreational Fishers

"I think this really focuses people because they are looking at their screen and nothing else. And if anything I think it [online workshops] might be better in terms of focus." – Chevron.

"*Software was great. Actually worked better than a whiteboard/post-it note session in the office*", "*I really liked doing this digitally over the web, in my opinion it was more focused than in face. More time to think*" – O&G

"*Very good facilitation. Good at capturing thoughts accurately and keeping the group focused*." – Chevron

"Worked very well in terms of having everyone 'at the table' and being able to see the facilitator 'link' up suggestions in real time!" – NGO

Social value individual and group comparison

A comparison of the results from the social value individual and social value group data was also undertaken. Overall, there appeared to be high levels of similarity between the findings providing corroborating evidence for the values, issues and opportunities. The social value data elicited from the group process, unsurprisingly, provided more nuance and a sense of relative importance (through prioritisation activities) and inter-connectivity (allowing a systemic perspective to be taken), whereas the survey provided a wider participation rate and thus adds robustness to the findings.

When comparing the values, the structure of the survey prompted respondents to consider ten values (elicited from the literature) allowing for comparison across demographics to be undertaken. The group focus workshops allowed the values to 'emerge naturally' (rather than being pre-selected). Despite these different approaches, on examination of the data, both research approaches identified healthy marine environments as being the most significant value as well as use (e.g. access, independence, wellbeing). The focus groups saw support for the ten survey values being surfaced and raised evidence based regulatory transparency and liability as additional important values (nine of the 11 workshops). Another area of value from the focus group workshops was that of effectively designing MMS, which was also raised by survey respondents in the open-ended responses, where a majority noted that MMS did not deliver negative social, economic or environmental consequences, "if done correctly".

Comparing the issues and opportunities, there was considerable homogeneity between the two data sets. However, there were differences in terms of coverage (the group workshops highlighting a number of dominant issues/opportunities that did not emerge from the survey) and in designation (in the survey some items were classified as opportunities whereas they were classified as issues by the group workshops). For example, the focus groups raised opportunities in terms of recycling materials and undertaking further research which the survey did not uncover. When considering different designations, the survey listed accessibility (ease of access) as an opportunity, whereas this was considered an issue by the group workshops. Similarly, environmental sustainability was seen as being a key benefit for the survey respondents, whereas the group workshops noted the issue of fish stock depletion (potentially the reverse of sustainability). However, for survey respondents how they viewed issues and opportunities depended on the question being asked. In the case of sustainability, overfishing was noted, but not as extensively as the opportunity for growing fish stocks. Illustrating the nuanced difference further. In terms of sustainability, the focus groups designated food sustainability as a value suggesting that not only were concepts differently designated between issue and opportunity, but also between issues/opportunities and value. These differences could be explained by the composition of the focus groups as compared with survey respondents as many of the focus group participants were decision makers, whereas the survey targeted users.

Section 4: Discussion

This section focuses on integrating the information obtained from the three data sets to provide a holistic perspective on these social and economic values and their inter-relationships. The discussion therefore synthesizes the views and perspectives of a range of stakeholders from different sectors, including recreational and commercial fishers, tourists and tourist operators, local council and chamber of commerce staff, people representing state government, conservation and fisheries agencies, regulators from state and commonwealth agencies, staff from NGOs representing commercial and recreational fishing, and conservation groups.

It is important to note at this point that there are sectors and stakeholders that are not represented. Attempts were made to collect and analyse indigenous views and perspectives on the values of MMS, but these were not successful. It should also be noted that the artisanal fishing sector, usually defined as small scale subsistence and commercial fishing activity utilising specific fishing gear, is not active in this case study area.

Eliciting and reflecting on socioeconomic values relating to MMS is important from both a procedural justice (Kim and Mauborgne 1995) and procedural fairness (Moffat and Zhang 2013) perspective as well as the more commonly considered rationality (Simon 1976) angle. Attending to justice or fairness closely relates to social license (raised as one of the values) to operate, which in itself goes beyond initial development and operation into decommissioning of O&G infrastructure (Genter 2019). Whilst decommissioning of O&G structures is often first to mind when considering MMS, paying attention to the social licence to operate relates to all projects. This is because stakeholder engagement is critical to retain social license (Eskerod and Lund 2013). Trust is a key element and effective engagement through meaningful conversations, rather than superficial consultation, has been found to be paramount (Genter 2019; Moffat and Zhang, 2013). Consequently, understanding the broad spectrum of stakeholders affected by MMS is important and thus engaging stakeholders to understand the breadth of values an important activity. This project sought the views of a range of different stakeholder groups seeking to ensure a comprehensive coverage of stakeholder groups (although recognising that there are some important omissions e.g. indigenous communities). It is also important to recognise the formal and informal links between stakeholders (Genter 2019, Ackermann and Eden 2011c). Considering stakeholders in isolation risks losing valuable support and increasing the chances of hostile coalitions.

In order to provide a visual summary of the social and economic values and their inter-relationships, three categories were identified and defined which collectively represent almost all values identified through the research. These are:

1) Use values. These are defined as the values that arise from the direct use of MMS and can be interpreted as economic direct use values and social values held by the individual reflecting their interaction with MMS.

2) Community values. These relate to a broader scale and can be interpreted as economic indirect use values and social values reflecting attributes gained by users arising from the presence of MMS.

3) Environmental values. These are associated with the quality of the marine environment, as this pertains to the presence of MMS. In economic terms, those values are existence or non-use values held by the general public, whilst social values reflect the significance of these environmental qualities to an individual.

Figure 41 depicts these value categories as three circles. Within each value category, there is an overarching value represented by a larger node which are hereafter referred to as ‘end state values’. Thus, ‘community benefits’ is the end state value in the ‘community values’ category, ‘user wellbeing’ is the end state value in the ‘use values’ category and ‘condition of marine environment’ is the end state value in the ‘environmental values’ category. Each end state value is influenced by other factors/values, which are represented by links to nodes, both within and across the three categories. It is worth noting that the

terminology used across components varies. For example, while in social science the node "safety" would be defined as a value, in economics safety is interpreted as a factor that contributes to the wellbeing of the user (end state value). As such, a hierarchy can be deduced.

The coloured segments around each node denote where each value was detected through the research activities. Thus, for example, 'job creation' is a community value which was identified through collection of data relating to economic values, individual social values and group social values. 'Pollution and water quality' is an environmental value which was identified through collection of data relating to individual and group social values, but it was not highlighted through collection of data relating to economic values. Hence, this figure does not indicate whether a certain node definitely has economic or social values attached to it, but rather reflects the outcomes of this research project (for example, it is possible to measure the influence that invasive species on MMS have on economic existence values, but this has not been measured here). Where all three coloured segments appear, it can be reasonably assumed that there is triangulation across data sources, and thus an increased weighting to the significance of that value.

Several values lie outside of the main categorisation outlined above. 'Social license to operate' and 'regulations' were grouped into a sub-category called 'rules and norms', whilst 'design of MMS' is a stand-alone value.

It should be borne in mind that this categorisation process may obscure differing stakeholders' interpretations and understandings of values (reflecting idiosyncratic perceptions). For example, 'safety' is a highly subjective value, reflecting an individual's perception of what constitutes personal or collective safety (e.g. proximity of MMS to shore, visibility of MMS, behaviour of individuals in and around MMS and so on). Thus, each value should be understood as including potentially different emphases or characteristics, whilst the importance attached to each value will vary within and between stakeholder groups. With that caveat in mind, the discussion will now examine each of the three main categories in turn.

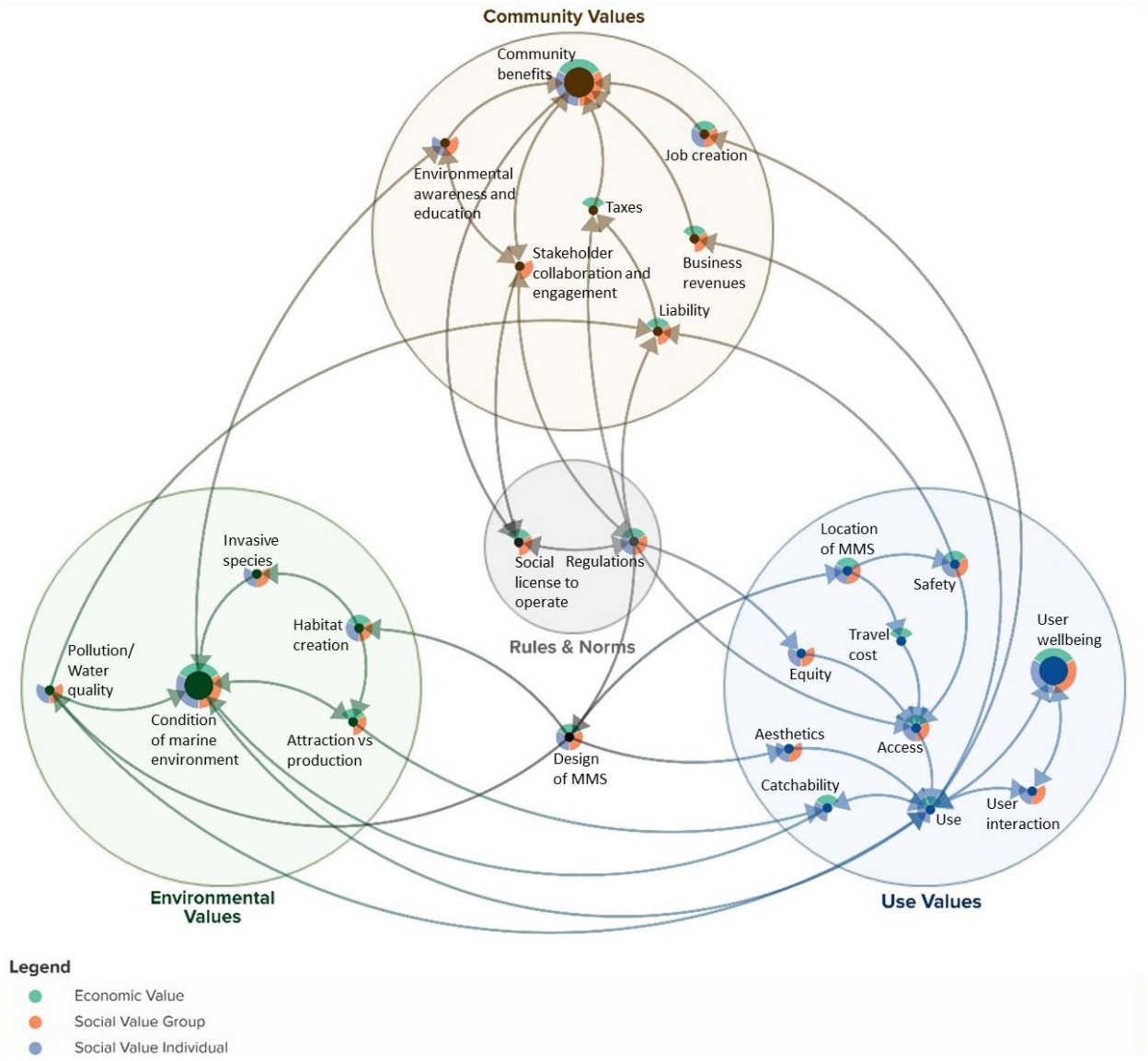
Use values

User wellbeing is the end state value in this category. This is influenced by individual use (including experiences of using MMS) and the benefits of interacting with other users. These in turn are conditioned mainly by access, which is a complex value composed of elements including the physical location of MMS, travel costs, personal safety considerations and any regulations defining rights of access for specific user groups. Use is also related to values in other categories, including job creation and business revenues and the condition of the marine environment. Accessibility was particularly important to recreational fishers and divers, who valued the enhanced opportunities for greater involvement and engagement with the marine environment. Economic survey data demonstrated a strong preference for MMS sites close to boat ramps due to the decrease in travel costs. Further depth to the notion of user wellbeing was provided by focus group work, which noted the cultural importance of MMS through fulfilling traditional lifestyle habits such as 'catching a snapper for dinner' and the aesthetics of the MMS.

However, it is important to consider how cumulative policy decisions may impact on these professed values. The economic data indicated an increase in consumer surplus value to both recreational fishers and divers as more sites are available, rising from $9.6 AUD per trip to an existing jetty to $11.9 AUD per trip to additional jetties for fishers and from $18 AUD to an existing shipwreck dive to $26 AUD for additional shipwrecks for divers. These results did not predict how the values per additional MMS change when creating numerous MMS in a region. It is likely that there is a saturation at some point and indeed, the social focus groups revealed that there was concern that whilst one or two MMS might be acceptable, a cumulative build-up of MMS could be perceived as losing the 'authenticity' associated with fishing and diving over natural sites. Results from the social survey also highlighted issues of overcrowding and inappropriate behaviour by some users impacting the enjoyment and well-being of others. Hence, MMS are also perceived as potential sites of conflict between different users. As an example, divers believe the

values of diving at MMS decrease in the presence of recreational fishers due to the prevalence of lost fishing equipment and rubbish on the seafloor and the behaviour of fishers. Similarly, the value that recreational fishers place on MMS decreases if commercial fishers have access. Commercial fishers want certainty over access to MMS, particularly if they were to invest in them, and stressed the need to recognise and reconcile different priorities within the sector (e.g. aquaculture versus line fishing). This result was supported by findings from the economic RUM survey which showed that recreational fishers have no significant value for shipwrecks which they have no access to. Accordingly, the discrete choice experiment found that the value of a rig-to-reef with access for fishers decreases significantly if the respondent is not a fisher, and slightly increases when the respondent is a fisher, indicating a non-compatibility of these activities. Conflict also emerged as a theme from the group social value data with conflict possibly occurring in the allocation/designation of MMS.

Figure 41: Integrated perspective on social and economic values of MMS.



Community values

Community benefits are the end state value in this category, with job creation being the only related value highlighted by all three research streams. Job creation evidently has many economic and social facets which would be desired by stakeholders, including direct and indirect employment opportunities, community stability and local identity. Business revenues and taxation are also important values generating community benefits alongside environmental awareness and education. Community benefits are directly

related to values outside of this category including social license to operate, whilst job creation is influenced by MMS usage as represented in the use values category.

Business revenues and the creation of jobs are flow-on effects of the direct use of MMS. For example, we estimated that people diving the Exmouth Navy Pier spend about $205 AUD for one day's diving ($615,000 AUD annually). We also found that the expenditures related to the Exmouth Navy Pier made up a substantial part of business revenues and employment for the operating dive company. For Busselton Jetty, the expenditure was estimated at $12 AUD per person per visit or annual expenditure of $6.4 AUD million. The case study on the Exmouth Integrated Artificial Reef showed it could generate between $155,000 and $1.05 AUD million for the local economy.

The economic importance of MMS was also particularly evident in the information generated by some of the regional focus groups and case studies where MMS were seen as a mechanism for creating local jobs and generating business revenues, and ultimately taxes which could be used to support regional infrastructure development and community programs. However, focus groups found that whilst it was appreciated that an increase in MMS could result in increased tourism for the area, there was concern that the increased tourist numbers would not only overwhelm the services used by members of the community but also potentially change the experience – touching on the 'well-being' value in a negative fashion. As such another balance, relating access to over access and thus ensuring sustainability was identified. This concern by the community was also found by the social online survey which noted the impact of increased usage - with a recognition that whilst tourism would benefit, there was in addition the potential for tension over resources such as food or fuel.

Commercial fishers can also benefit economically from MMS. Commercial trap fishers have been documented fishing near offshore O&G structures periodically (Bond, 2020). Another example of commercial fishing/aquaculture benefitting from MMS is the design and deployment of purpose-built artificial reefs to allow in water sea ranching business for abalone (see https://www.oceangrown.com.au/). Some commercial fishers believed that the construction and deployment of purpose-built artificial reefs were one mechanism available to them for increasing their profitability. Challenges to pursuing this option for enhancing fishing and profits were the current legislation for deployment and installation of artificial reefs and obtaining exclusive access rights – touching again on the regulation transparency value. Also, the social - individual survey found that commercial fishers and other stakeholders were less inclined to agree that MMS deliver environmental benefits although the social group workshops did see environmental values being subscribed to, but with less weight than economic. This underlies a need to demonstrate the environmental benefits of MMS if seeking to gain widespread community support.

One challenge that was found by all components was the question of who assumed the long-term liability for MMS. The focus groups revealed that there is a perception by some stakeholders that O&G companies wanted to 'dump' their rubbish on the seafloor under the guise of a 'rigs-to-reefs' program and transfer liability to the government. This perception led to one of the most frequent concerns raised which was who was responsible for the maintenance of MMS and the liability and costs of removal at the end of its life, or for the costs of clean up if an unforeseen event occurred. This was particularly relevant to discussions around decommissioning offshore O&G infrastructure and was part of the discussion around the need to reduce regulatory uncertainty by having clear and consistently applied guidelines both for decommissioning and the installation of new structures. Similarly, the economic discrete choice experiment showed that the WA general public preferred decommissioning scenarios where the future liability lies either solely with the O&G companies, or jointly between the O&G companies and the Australian government.

The results from some of the focus groups revealed that it was a complex arena to navigate. For example, the uncertainty around the regulatory framework, and the short and long-term environmental impacts when compared against the potential social, economic and environmental benefits, has an effect on the social licence to operate and therefore needs to be taken into account by any proponent wanting to install or relocate MMS. Accordingly, the social online survey found that the enhancement of community benefits is seen to contribute towards a social licence to operate, thereby creating a feedback loop between individual perceptions of community benefits and the broader policy environment. Then again, the

economic discrete choice experiment suggests that members of the WA general public that grant a higher degree of a social license to operate to the O&G sector are more likely to prefer decommissioning options that convert O&G infrastructure into artificial reefs.

There was a belief among focus group participants that if the process of designing, constructing, deploying, and monitoring MMS was undertaken with meaningful and collaborative stakeholder engagement that an outcome could be increased community awareness of the marine environment promoting environmental stewardship. The opportunity for increased environmental awareness associated with MMS was also found by the social online survey as an additional component of community benefits.

Environmental values

Condition of the marine environment is the end state value in this category and was highlighted by all three research streams as the most central and important value. The workshops highlight the centrality of ensuring a healthy marine environment with all 11 workshops raising this as a value and the vast majority prioritising the themes supporting it. This value is influenced by pollution, water quality and the presence of invasive species and in turn influences whether MMS act as sites of attraction or production for marine species. Habitat creation is related to the latter, and also influences the presence of invasive marine species. The condition of the marine environment is also affected by values in other categories, principally those associated with use and catchability, but also interacts with values associated with environmental awareness and education. Rules and norms and MMS design do not directly influence this end state value but do interact with pollution and water quality.

MMS often have unique assemblages of marine organisms, and in the case of some artificial reefs, jetties and piers, O&G platforms and pipelines the biomass of fish exceeds nearby marine habitats (Bond et al., 2018a, b; Schramm et al., 2020). In part, this is because some of these structures are not fished (platforms), but also because the sometimes vertical and complex engineering of the structures create a number of different habitats and ecological niches for organisms to occupy (McLean et al. 2019). Habitat creation was frequently cited as an important value and driver in the online survey of social values, whilst focus group work revealed a broad range of environmental benefits associated with MMS including increasing or improving local fish stocks, biodiversity and overall ecosystem health.

There was also a belief that MMS benefited the marine environment by diverting recreational fishing and other pressures away from natural habitats – although care had to be taken as the provision of well sited MMS could result in overfishing (both at the site of the MMS and from surrounds as fish moved from one location to another). Economic valuation surveys highlighted the presence of non-use values, whereby individuals valued the environmental contribution from MMS regardless of whether they personally benefited from it. These non-use values (expressed as consumer surplus) were higher where O&G infrastructure generated a higher fish biomass and/or habitat for endangered species. The study also found that production of new fish biomass was preferred over attraction of biomass from the surroundings. Whilst the social and economic benefits arising from the impact of MMS on the marine environment were noted across all stakeholders, there were clear differences in nuance. For some focus group respondents, the emphasis was on protecting the environment, whilst for others it centred on rebuilding the environment (restoration), which may reflect whether respondents had a pristine or damaged marine environment in mind and the activity they participated in.

In addition, in the social values online survey and workshops, stakeholders raised issues and concerns about the installation of MMS including potential pollution (whether that be from the gradual disintegration of the structure or the aesthetics - visual pollution) and a degradation of the marine environment due to MMS. It was also noted that they could become stepping-stones for the spread of invasive marine species suggesting careful management and design would be needed. Focus group participants were also concerned that an overuse can lead to detrimental environmental impacts such as pollution and a reduction in the quality of the marine environment due to over-consumption. There was a concern from focus group participants that current policy and legislation was unable to reflect what

stakeholders wanted and needed. This was particularly the case for decommissioning of O&G infrastructure where decommissioning options were supported on the premise that decommissioning was evidence based, addressed community and regulator concerns about pollution, habitat degradation, and invasive marine species and benefitted a broad range of stakeholders, including diving and conservation.

Rules and norms

When looking at the synthesis and integration of the information generated by the research (Figure 41), it is evident that regulations and MMS design are key drivers of values within the use values category. It was therefore necessary to include a small subcategory entitled 'Rules and Norms' to reflect the importance attached to regulations and a social license to operate. These values are closely related and underline the importance of regulations that were seen as transparent, consistent and evidence based. A failure to adhere to these values would negatively impact all three end state values in the other categories. Regulations exert an influence on this flow of use values through determining how and when users can access MMS, whilst MMS design determines location, type of construction and the capacity of the MMS to support multiple user groups. This raises the issue of resource allocation and sharing and implies that the purpose of the installation of an MMS needs to be well defined in advance, which may lead to specific types of MMS being allocated to specific stakeholders/user groups at some locations. To some extent, this already occurs with recreational fishing on shipwrecks such as the HMAS Swan and Perth banned so that these wrecks are for the enjoyment of recreational divers only. Resource allocation can result in better outcomes for all users which will ultimately lead to greater user wellbeing being derived from MMS. It was noted in the group value workshops that more research into the justification for MMS in terms of designated users was an important activity. The focus group work also revealed that such a failure could manifest through a lack of clarity in policy, incidents associated with MMS acting as hazards to individual or commercial activities, or evidence of contamination arising from MMS degradation or disintegration.

Section 5: Conclusion

This research had four objectives:

1) To augment and integrate analytical methods to identify and explore the socioeconomic values of MMS structures in Western Australia.
2) To collate a list and description of the MMS in the marine environment in Western Australian and the associated social, economic and biodiversity data.
3) To collect and collate data on the social and economic values of MMS in Western Australia including five case studies.
4) To develop a guide for undertaking socioeconomic evaluations of MMS which can be used throughout Australia (and other locations) and direct end users on approaches and strategies depending on their information requirements.

These objectives have been fulfilled, and the information generated by this project provides a strong foundation to inform decisions and facilitate acceptance of MMS across diverse user groups into the future.

As a generalisation, most stakeholders believed that there were social, environmental, and economic values associated with MMS. However, concerns were raised about issues such as habitat degradation and marine pollution due to chemicals leaching or leaking from structures.

In order to address these concerns policy must be informed by case studies that present robust and independent environmental, social and economic data and engage the stakeholder community.

There was also a consistent call for greater regulatory certainty. Moreover, a part of that regulatory framework needs to address potential conflict between different users of MMS by providing mechanisms to allocate the use of specific structures to a particular sector and/or to incorporate property rights.

The opportunity

In coming years, there will be increasing numbers of proposals to create and deploy MMS. Whether this is through the creation of new ports and jetties, the installation of offshore renewable energy, artificial reefs, or other types of infrastructure, there is a need to maximise the environmental, social and economic benefits that can be gained from the installation of these structures. This can be done through eco-engineering which aims to maximise the ecological value of future structures by incorporating knowledge of ecological processes into engineering design principles (Chapman and Underwood, 2011; Dafforn et al., 2015; Todd et al., 2019).
By also considering the socioeconomic values of all potential stakeholders (as illustrated by this report) during planning processes, it will be possible to maximise the social and economic benefits to potential users (Lacroix and Pioch, 2011) and avoid adverse stakeholder responses (and attendant costs). Where structures have a temporary lifetime, engineers need to ensure that structures can be easily removed from the seafloor, and when they cannot, they need to ensure that the structures that are left in place are designed to be environmentally friendly and meet the social and environmental values and expectations of the community thus addressing the regulatory considerations raised in this report.

Implications

The work of this report has established the benefits of MMS via international and domestic peer reviewed research and the case studies we present. This information provides a means to bridge otherwise disparate stakeholder groups' views. These benefits can be realised over short timescales and can be described in

accessible, non-technical terms. Building a consensus and positive view on MMS through reference to these attributes will help mitigate any adverse perceptions and values.

Section 6: Recommendations

1) The Environmental Protection (Sea Dumping) Act 1981 is the key approval required for an artificial reef permit for any purpose-built or integrated reefs. While the assessment for this permit considers impacts on stakeholders the key underlying principle for the decision making is environmental, not socioeconomic values or benefits. The socio-economic values and benefits is what drives the funding and support (upfront and ongoing) for proposals in the first instance. Socioeconomic values and benefits are important considerations for future MMS implementation. Consequently, it is important that the outcomes of this research are broadly socialized and communicated – for example via webinars (https://wamsi.org.au/news/webinar-the-value-provided-to-fisheries-by-man-made-aquatic-structures/), academic and non-academic papers and presentations. The proponents of the research will need to plan how to achieve this effectively.
2) Understanding socio-economic values and benefits is a key component to guide any future decisions about MMS.
3) There is a need to demonstrate the environmental benefits of MMS if seeking to gain widespread community support.
4) There is a need to develop greater regulatory clarity around the installation and removal of man-made marine structures (e.g., expanding and building on the Offshore Petroleum and Greenhouse Gas Storage Act 2006; developing guides for the assessment of permit applications for artificial reefs under the *Environmental Protection (Sea Dumping) Act 1981*). There needs to be clear guidelines developed across all levels of Government that reflects the needs of all stakeholder groups. While challenging, the objective would be to develop clear and transparent guidelines (or policy frameworks and regulations) that are consistent across the country. Specific suggested changes to guidelines or regulatory reforms should consider the following:
    a. policy development that seeks to guide future proposals for the installation of purpose built and integrated (using repurposed subsea infrastructure) reefs in Australia.
    b. incorporating social and economic data that reflect the values, issues and opportunities raised by stakeholders to maximise benefits is an important consideration for any guidelines. Highlighting benefits is essential for the development of social license for a wide range of projects from decommissioning of O&G infrastructure to the design and installation of artificial reefs, and the development of harbours and ports that are environmentally appropriate.
5) In Western Australia, the development and implementation of purpose-built artificial reefs in WA commenced in 2012. Since 2012, seven artificial reefs have been installed without any inter sector conflict. All reefs belong to the wider community. The key has been appropriate constraint mapping and consultation among multiple stakeholder groups prior to reefs being fabricated and deployed. This is a fundamental principle for any ongoing program.
6) There is a need to review the legal liability of MMS in general across governments, with the goal being to maximise the social and economic value that may arise from the development of MMS. In addition, consideration needs to be given to the development of explicit frameworks that identify end of life liability, as well as the costs and actions needed for site remediation and/or creation of MMS.
7) Importantly, there needs to be a more strategic approach to habitat enhancement structures in all jurisdictions. At present many purpose-built artificial reefs are simply located based on political desires and/or because there is a proposed decommissioning opportunity at the site. A more strategic approach is required from industry to validate and justify where purpose-built reefs are placed with a long-term vision to enhance both fish production and amenity value.

8) That further research on key gaps in ecological knowledge is needed to understand the net benefit of MMS for enhancing the condition of the marine environment: e.g., whether MMS provide habitats that increase fish productivity (or just act to attract and aggregate fish stocks); whether MMS are important for the protection of vulnerable species; how MMS will degrade over time and what environmental impacts may result, whether MMS could increase the risk invasive marine species.

Further development

Although the objectives of the project have been fulfilled, there are a number of limitations to the research, and a number of additional research outcomes emerged that should be pursued

Limitations:

1) We acknowledge that this research does not incorporate the values of indigenous stakeholders and that their input and values will be important in the development of any future management plans. The timeframe, resourcing and expertise of the research team precluded this. The values of indigenous people from across Western Australia and Australia should be explored and taken into consideration.
2) This research provides a snapshot of stakeholders' values and the economic and social outcomes (both positive and negative) of interactions with MMS in Western Australia. To be more comprehensive we recommend that this research is scaled to incorporate the views of stakeholders from other states (more broadly than was possible in this study).
3) The evaluation of MMS was framed by the current provision, or only marginal changes in it. However, over the next 30 years there will be substantial, non-marginal changes in MMS (e.g. from decommissioning or major infrastructure developments.

Further research recommendations:

1. There were a number of re-occurring arenas for potential conflict relating to MMS illustrated through different uses not being compatible thus raising the issue of resource allocation. From an economic perspective, the ability to quantify the relative values of a structure to different users may assist with allocation decisions. With comprehensive regional data on people's values and wants, combined with ecological data it is possible to develop a spatial allocation model to optimise the outcomes of deploying different types of MMS in different locations for different users.
2. Proposals for the installation of MMS needs to be cognisant of the different stakeholder values and benefits and tailor each to fit the local context (as context is important) and ensure equity and sustainability. As such, developing a process to facilitate each proposal – attending to inclusivity and systemicity – and capture learnings would provide an important resource for decision makers.
3. Due to the cumulative impacts of human activities, there is a loss of both condition and area in terrestrial, estuarine and marine habitats. There are significant attempts globally to restore critical habitats (Miller and Hobbs, 2007; van Katwijk et al., 2016) and it has been suggested that artificial reefs may be used as a tool to enhance the productivity of essential fish habitats and generate economic return to commercial fishers (Kasim et al., 2013; Yu and Zhang, 2020). We believe there is the need to consult with commercial fishers to determine whether there is the need or want to develop a broad scale trial which investigates the economic benefits to commercial fishers of deploying structures which are purpose built to drive production, growth and catchability.
4. Invasive marine species occupying MMS and using them as a mechanism for spreading was a consistent concern/issue raised. Research does need to be undertaken exploring whether this is a reality or a belief as well as the means for managing IMS should they occur.

Section 7: Extension and Adoption

The project outcomes were communicated to industry, Recfishwest, WAFIC and state government through steering committee meetings. A webinar was hosted on the 17th of December 2020 as a COVID-19 safe way of communicating the outcomes to a broader audience.

Where opportunities present themselves, we will continue to promote the outcomes of this research.

Project coverage

The project was promoted in the Fisheries Research & development Corporation News (FISH, Volume 28(2) pg 16-17.

FRDC also did a media release on the 5th of October 2020 https://www.frdc.com.au/media-publications/news-and-media-releases/Oil-and-gas-infrastructures-become-fish-havens which resulted in an interview with the ABC Pilbara on the 6th of October. GWN also did an article to air on the 6th of October 2020 https://www.gwn7.com.au/news/30335-fish-havens.

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Section 9: Appendices

Appendix 1 Man-made marine structures in Western Australian coastal and offshore waters
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