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

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This appendix is part of the final report for:

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

Euan S. Harvey, Fran Ackermann, Michael Burton, Julian Clifton, Carmen Elrick-Barr, Johanna Zimmerhackel, Georgina Hill, Stephen J Newman, Jenny Shaw, Mark Pagano, Paul McLeod, Dianne McLean, Julian Partridge

21 August 2021

FRDC Project No **2018-053**

The data on MMS in Western Australian coastal and offshore waters is available online through various routes:

Here is the link to the web app:

https://aimsdata.maps.arcgis.com/apps/webappviewer/index.html?id=e534ab2975f64ca68479cc291dcb3a9f

The web app is primarily for viewing and interrogating data, although one can download data from it one dataset at a time.

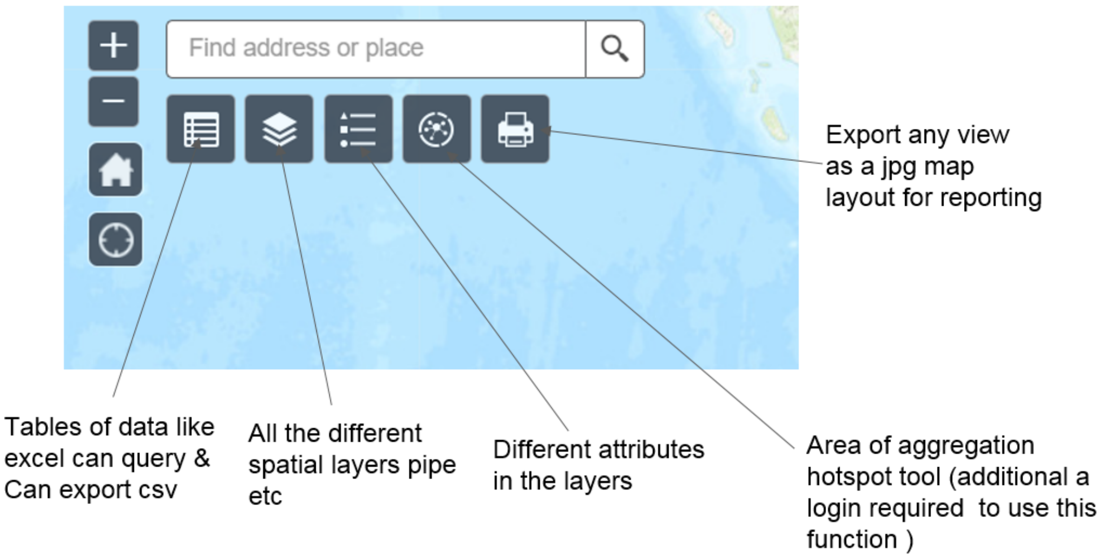
As well as the web app link, you can download the data from the link below, or access it directly in ArcGIS, ArcPro or QGIS GIS systems:

https://aimsdata.maps.arcgis.com/home/item.html?id=afeddcca05a44789a946623d01a32376

ESRI requires a sign-in to access the data. It can be either by using an institution ESRI account, generating a free ESRI account or via an existing google, apple, facebook or github account.

If accessing the data through the web app, the following figure gives some information on functionality.

How to use the FRDC mapping tool functions/widgets cheatsheet



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FISHERIES RESEARCH &
DEVELOPMENT CORPORATION

Appendix 2 Socioeconomic values associated with man-made aquatic infrastructure academic literature review

Dr Julian Clifton, Dr Carmen Elrick-Barr, Dr Johanna Zimmerhackel & Ms Georgie Hill

This appendix is part of the final report for:

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

Euan S. Harvey, Fran Ackermann, Michael Burton, Julian Clifton, Carmen Elrick-Barr, Johanna Zimmerhackel, Georgina Hill, Stephen J Newman, Jenny Shaw, Mark Pagano, Paul McLeod, Dianne McLean, Julian Partridge

29 January 2021

FRDC Project No **2018-053**

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

Draft Final Report: Socioeconomic Values Associated with Man-made Aquatic Infrastructure Academic Literature Review

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Introduction

This Report details the outcomes of a literature review pertaining to the social and economic values and perceptions of man-made aquatic structures in the marine environment which was conducted as part of the FRDC Project entitled 'Enhancing the Understanding of the Value Provided to Fisheries by Man-Made Aquatic Structures' (FRDC 2018-053). A summary of this Report was presented to the Project Steering Committee on 21 November 2019.

The objectives of the literature review are as follows:

- Understand the scope of academic and professional literature addressing socioeconomic values of man-made aquatic structures in the marine environment
- Understand best-practice approaches to inform research methods
- Understand the values of man-made aquatic structures in the marine environment, by stakeholder group and/or structure type to enable future comparative analysis with case-study areas

Structure of the report

This Report begins by defining the terminology relating to social and economic values and perceptions through reference to key principles and literature. The processes through which relevant publications pertaining to these topics in the academic and professional literature are identified. These are then reviewed to ascertain the state of knowledge regarding social and economic values and perceptions. The final discussion section identifies key gaps in this knowledge with reference to the case study sites for this project and the next stages of the research.

Definitions

Economic value

This is defined as the total economic value (TEV) of direct use values, indirect use values and non-use values.

Direct use value

These represent the benefits arising from the immediate use of a marine man-made structure in the form of outputs that can be consumed or enjoyed directly (for example, extractive uses such as fishing or aquaculture; non-extractive uses such as diving).

Indirect use value

These represent the benefits that a marine man-made structure provides to support other economic activities, or positive externalities that affect other users of the marine environment (for example enhanced fish biomass through habitat protection, diversion of effort from other fishing or diving sites)

Non-use value

These represent the benefits arising from knowing that a marine asset has been conserved (termed existence and bequest/altruistic values) or may be available for use at a later date (termed option value).

Man-made aquatic structures in the marine environment

Any artificial structure in the marine environment, including artificial reefs, jetties, oil and gas infrastructure (including pipelines), piers and shipwrecks. These are collectively referred to as MMI (man-made infrastructure) for ease of reference in this report.

Model

A representation that describes and simulates reality, relationships, decision making and/or behaviour. Different models produce, and require, different types of information (shared) and take into account different perspectives and stakeholder needs

Secondary data

Existing data sources and literature.

Social value

A desirable goal based on what a person or group perceives as valuable and important that influences actions, behaviours, attitudes, and norms (O'Connell et al., 2018).

Methods

The systematic literature reviews were conducted separately by the social and economic research teams. As such, the methods are presented separately for each theme. However, the research teams collectively defined search criteria and approach (e.g. databases) to ensure consistency. In addition, literature was shared between the teams. For example, papers addressing social values identified in the economic value systematic review were shared with the social values research team, and vice versa.

Social Value Methods

Academic Literature Review

A systematic literature review of academic literature exploring the topic of social values and man-made marine structures was conducted across the Scopus, Web of Science and Google Scholar databases (see Figure 1). Database queries were conducted using synonyms for 'social values',' 'man-made aquatic structures', 'uses' of structures, and 'objectives' of structures (see Appendix 1 for search terms). This initial search produced 327 articles. Abstracts of these articles were evaluated based on inclusion/exclusion criteria[1] and reduced to 75 articles. These 75 articles consisted of peer reviewed journal articles written after 1989 in English with an explicit focus on the social value of man-made marine structures. During the review process, 38 additional articles that appeared relevant to the review, but were not captured via the systematic review protocol were included and reviewed. For all articles meeting the secondary criteria (N = 113) full text review was undertaken.

Each article was ranked according to its focus on social values and man-made marine structures (MMI). A three star rating system was applied. Three star papers addressed social values and/or perceptions in relation to MMI, while two star papers addressed one of these topics with minor reference to the other. One star papers did not provide the level of detail required to interrogate social values and MMI, but may have contained an element/aspect that could be useful for later stages of the project. Papers that did not address any of the review topics were removed. All articles that received a 2- or 3-star rating (N = 26) were examined to explore the: geographic focus; stakeholder groups involved; social values examined/addressed; methods of stakeholder engagement; methods of social value assessment; findings in relation to social values by stakeholder group.

Professional Literature Review

The review of professional literature (grey literature) covered reports and other publications produced by, or stored by, marine-based professional industries and organisations. The professional literature review focussed on the case location (i.e. Australia) and countries with similar resource and management conditions (i.e. United Kingdom and the United States of America)[2]. Two approaches were applied to profile the literature: (i) a search of industry organisation's websites using synonyms for 'social values',' 'man-made marine structures', 'uses' of structures, and 'objectives' of structures; and (ii) recommendations from technical experts. The initial search produced 38 publications. Executive summaries were reviewed based on inclusion/exclusion criteria[3] and reduced to 13 publications. Full review was completed for each of the 13 remaining publications and each was assigned a rating using the 3-star system (as per the academic literature

[1] Refer to Appendix 1

[2] Refer to Appendix 1 for further detail.

[3] Refer to Appendix 1 for further detail.

review). The 2 and 3 star publications (7 in total) were interrogated to find trends in geographic focus, stakeholder group(s), social values explored, research methods and key findings by stakeholder group.

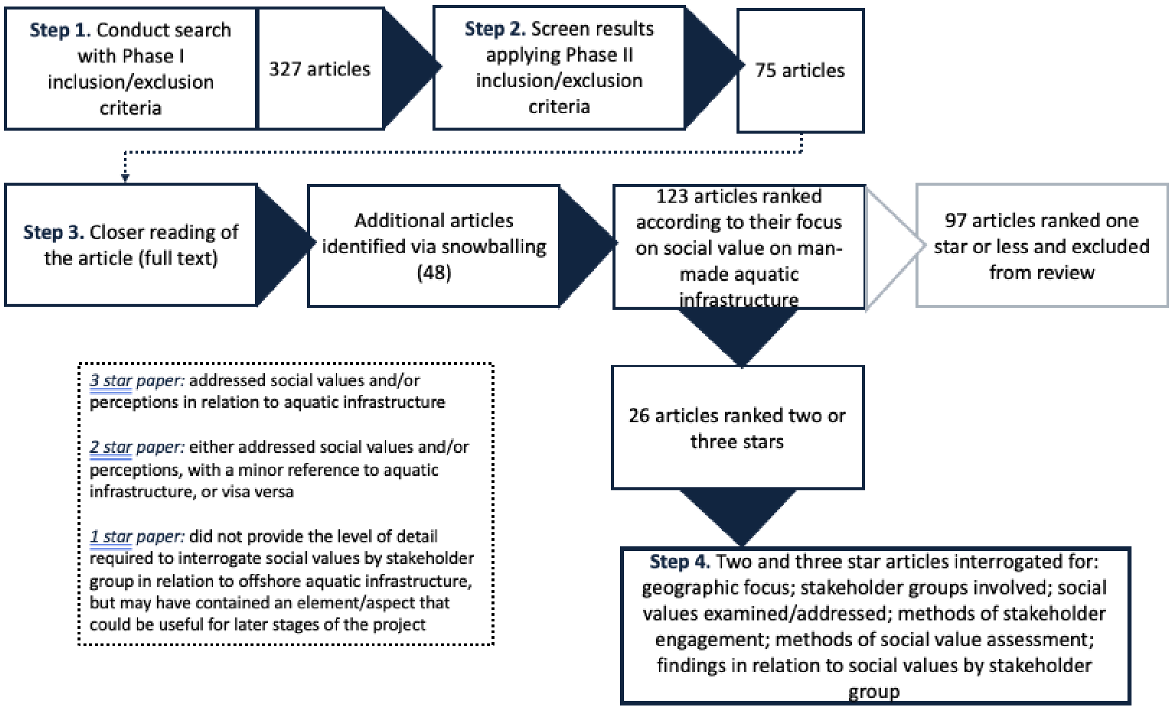

Figure 1. Social Value in Man-Made Aquatic Structures Academic Literature Review Process.

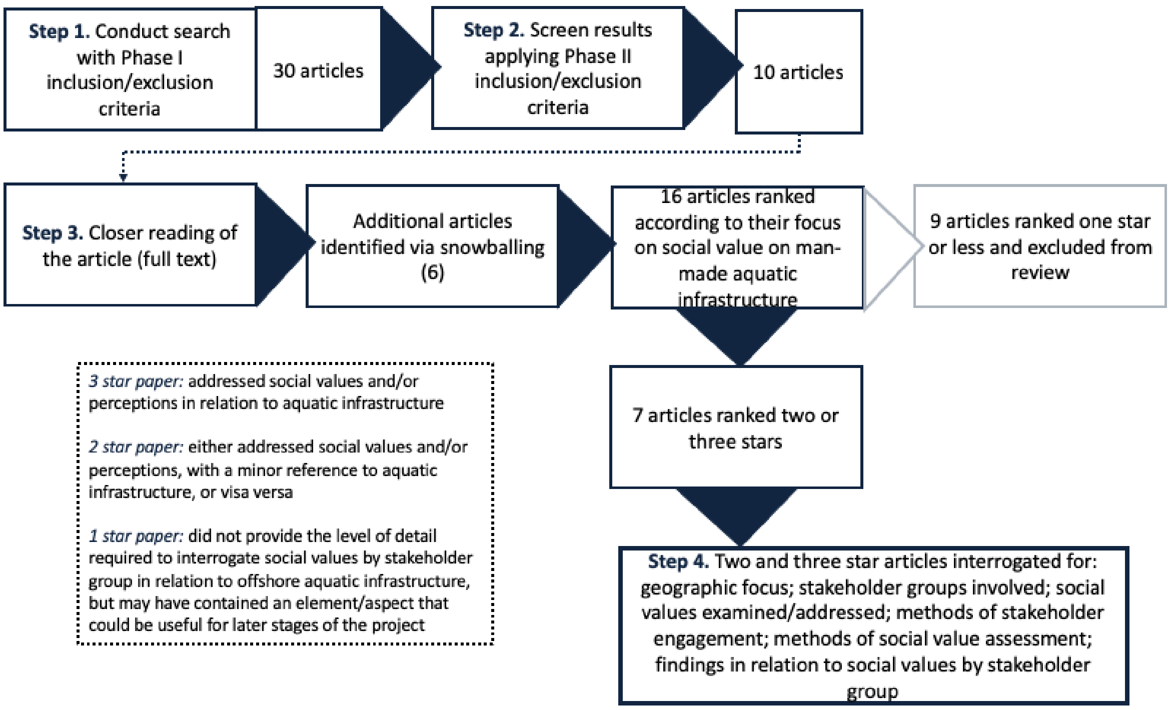

Figure 2: Social Value in Man-Made Aquatic Structures Professional Literature Review Process.

Economic Value Methods

Conceptual framework of economic valuation of marine man-made structures

Economic values associated with the natural environment are usually described in various value types which together add up to the total economic value (TEV). This TEV framework has been widely applied to measure the change in values when interventions impact on the natural environment, such as the development of artificial reefs in the marine environment. Table 1 shows the benefits of artificial reefs within the TEV framework. Direct use values include consumptive and non-consumptive use values, with consumptive use values covering the values that result from extractive uses such as commercial and recreational fishing around artificial reefs. Non-consumptive use values are derived from usages that do not diminish the amount of the resource. For example, artificial reefs provide non-consumptive use values through recreational activities such as diving, surfing and. Indirect use values are benefits that artificial reefs generate in the marine environment which affect other economic activities. These benefits include various reefing effects such as habitat enhancement, increased fish production and coastal protection. Different from the direct and indirect use values which are commercial in nature, non-use values result from the satisfaction that people derive from goods or services, without them necessarily having to interact directly with the resource. This can be for example peoples' value for knowing that a natural resource has been conserved or improved without necessarily using it. In the context of marine artificial structures, non-use values include, the knowledge that artificial reefs have increased species diversity (existence values) or conserved a species for future generations or other people (bequest/altruistic values).

Table 1: Values attributed to marine man-made structures (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 marine man-made structure 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 marine man-made structure 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 at a later date (option value). Examples: - Knowledge that reef-based protection has increased marine biodiversity - Knowledge that a unique habitat is conserved intact for future generations

There are various methodologies to quantify the economic value of a good or service, which can be separated into market and non-market valuation techniques. Market valuations quantify values from the market prices for the good or service being valued and the quantities purchased. This technique is therefore limited to goods and services that are traded in markets (such as products related to tourism and recreation, or fish). Conversely, non-market valuation methods allow goods and services to be valued which are not traded in markets. Non-market valuation methods can be further divided into stated preference and revealed preference techniques: Stated preference techniques (such as contingent valuation, contingent behaviour, and discrete choice experiments) use surveys with questions that typically present respondents with a hypothetical change in an environmental condition to determine how much they are willing to pay for this environmental good or service. Revealed preference techniques (such as the travel cost method and hedonic pricing), in contrast, can be applied where the value of goods and services affect markets without being directly traded within them (Hanley et al. 2019).

Conceptually, the economic value derived from the acquisition of any good, service, or experience, whether purchased in a market or acquired by non-market means, is measured in monetary terms by the willingness to pay (WTP) for that good, service, or experience. Therefore, the economic value of each recreational fishing or diving trip is the maximum amount of money that a given person (e.g. a recreational fisher or diver) would be willing to pay for the trip. The demand to go fishing or diving can be represented by a conventional demand curve (Figure 1) where the chosen number of trips per year is a function of the WTP for the trip. The total value derived from a given number of trips is the area under the demand curve (equivalent to the area ABCO) and is called the gross WTP. Recreational fishers and divers choose to expend resources because the value derived from fishing or diving is greater than or equal to the value of these resources expended in some other way, so the value of expenditures is a minimum or lower bound estimate of the value of recreational fishing or diving (shown as the area EBCO). The excess of the WTP over and above resource costs incurred is the consumer surplus (or net WTP) from the recreational fishing or diving experience (shown as the area ABE). Hence to estimate the gross WTP, an estimate of the consumer surplus is added to the estimated expenditure.

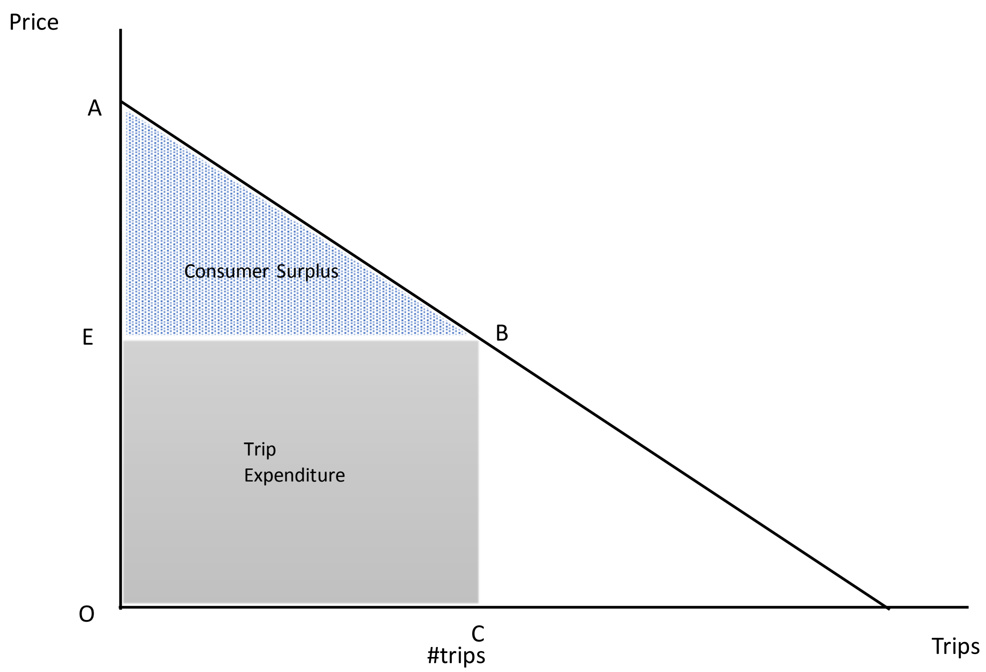

Figure 3: Expenditure and consumer surplus of recreational activities

Literature Review

We conducted a systematic review of the national and international literature on economic values of marine man-made structures. The steps of the search protocol are illustrated in Figure 2. A recent report from the National Environmental Science Program (NESP) conducted a literature review on the economic value of artificial reefs which we used as a base (Blackmore et al. n.d.). This literature review included 26 studies meeting the following eligibility criteria: (i) written in English language, (ii) has a reference to either market or non-market valuation of artificial reefs in title, keywords or abstract, (iii) is primarily a valuation study on artificial reefs, (iv) quantitatively estimates values of artificial reefs and (v) was published by scientifically-reputable sources e.g. peer-reviewed journals, book reports, project reports, academic theses or government agencies. The approach was appropriate because the report used a broad definition of artificial reefs as any man-made structure in the ocean which fitted the scope of this project.

Additionally, we ran a literature research using the Web of Science database, Google Scholar, and a snowball technique by analysing the reference lists of relevant studies. We ran a search string in Web of Science and Google scholar to find literature on marine man-made structures for each of the structure types relevant to this report, namely: artificial reefs, oil and gas platforms, pipelines, and piers and jetties. This yielded a total of 268 studies that met the phase I inclusion/exclusion criteria: (i) written in English language, (ii) has a reference to the economic value of one of the four structure types in title, keywords or abstract and (iii) was published by scientifically-reputable sources e.g. peer-reviewed journals, book reports, project reports, academic theses or government agencies. The studies were then analysed in more detail by screening of their abstracts (and where necessary their full-text). Studies were regarded as eligible when they fulfilled the following Phase II inclusion/exclusion criteria: (i) is primarily a valuation study for the specific structure type and (ii) quantitatively estimates values of this structure type. The articles found together with the NESP articles yielded in 29 studies. An additional six articles were found through the snowball technique by screening the reference lists of eligible studies.

For each of the 35 identified valuation studies, we extracted information about the purpose of the structure, the measured value type(s); data collection year; valuation method(s); country in which the study was conducted; valuation context or question; and willingness-to-pay estimate. Moreover, we converted all of the value estimates from the relevant studies to 2019 USD to present consistent and up-to-date values. We did so using online sources for the Consumer Price Index for the relevant countries (*World Bank Open Data | Data* n.d.) and a currencies converter (*XE - The World's Trusted Currency Authority: Money Transfers & Free Exchange Rate Tools* n.d.).

Where we found less than five economic valuation studies for a particular structure type, we searched the initial 268 articles that met Phase I criteria for studies that mentioned the economic importance of these structures without quantifying them. This was the case for piers and jetties as well as for pipelines and yielded zero and nine articles, respectively. We extracted relevant quotes referring to the economic value of these structures.

Overall, this process resulted in 44 relevant studies: Artificial reefs (29), oil and gas platforms (6), piers and jetties (0), pipelines (11). Please note that two studies fit into the artificial reef and the oil and gas platforms categories which is why the sum of these articles does not add up to 44.

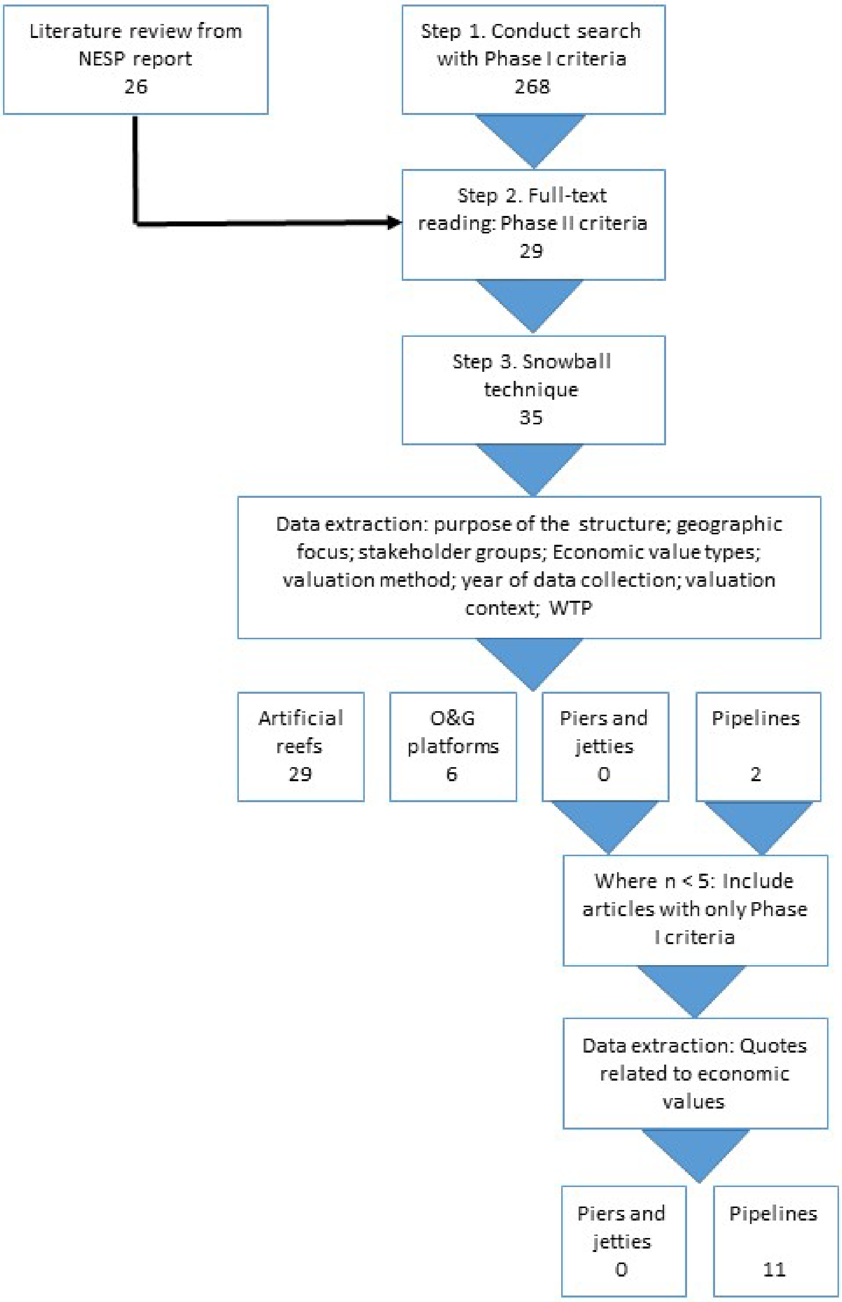

Figure 4: Literature review process and number of eligible studies per type of marine man-made structure.

Findings

Social Value Findings

In this section, the results of the systematic review of the social value literature are presented. The discussion of findings is limited to the literature classified as 2 or 3 stars. We commence with an overview of the geographic scope of the papers, the coverage of structure types and stakeholder groups. We then focus in more detail on the types of social values examined and finish with presentation of the conceptual model developed.

Scope of the papers.

Artificial reefs were the dominant man-made marine structure (MMI) addressed in the reviewed literature (see Figure 2). Structures not classified as MMI, such as natural reefs or marine protected areas, were the second most common structures. Papers on social values beyond MMI were included in the review when identified via the search criteria and containing a strong focus on social values useful during later stages of this project. The third most common structure was oil and gas platforms.

The three most common geographic regions discussed in literature were Australia, the US and the UK. It should be noted that the literature from Australia came predominantly from the Eastern States (see Figure 3). A majority of papers addressed either a single stakeholder group (e.g. divers), or multiple stakeholder groups. Commercial and recreational fishers were the two groups discussed most in reviewed papers (see Figure 4).

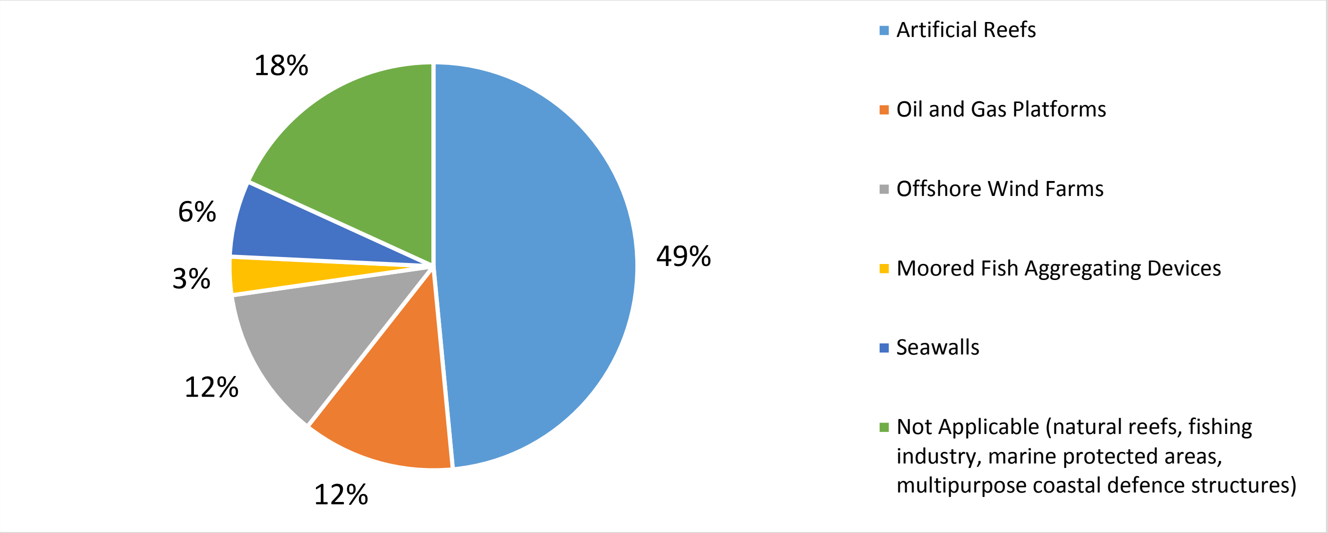

Figure 5. Breakdown of structure types discussed in social value literature review.

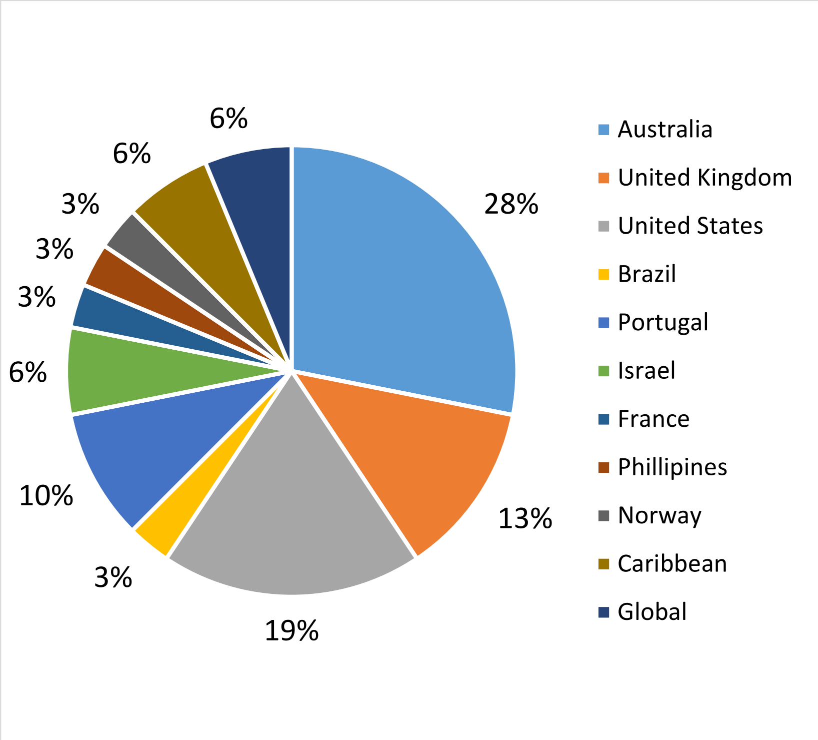

Figure 6. Breakdown of geographic regions discussed in social value literature review.

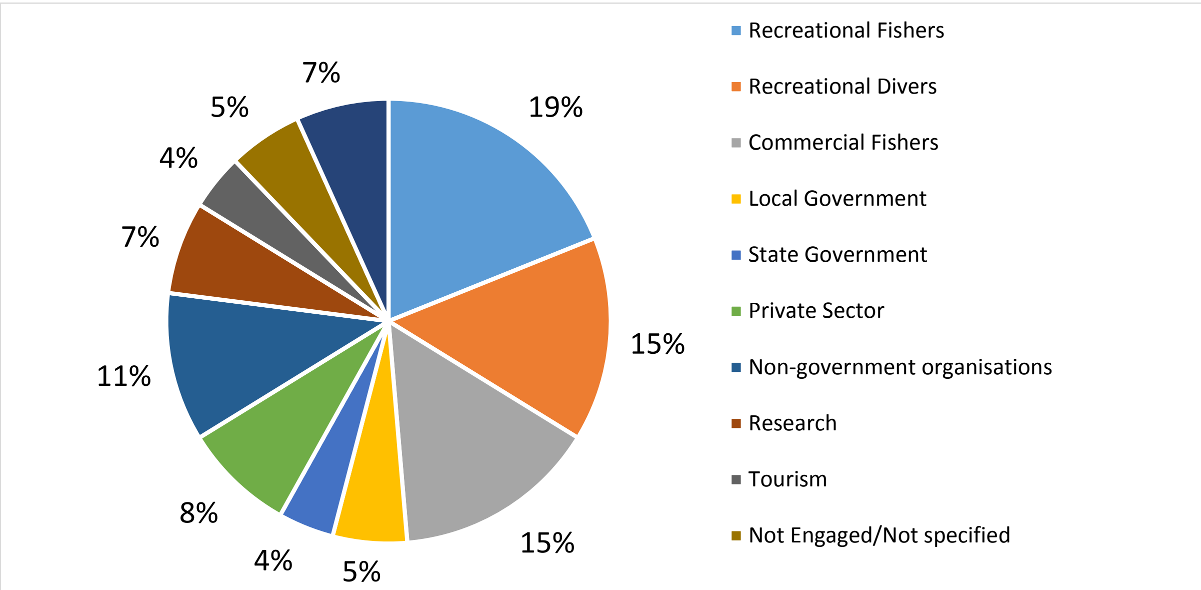

Figure 7. Breakdown of stakeholder groups discussed in social value literature review.

Social values assessment

The social values assessment of the literature review sought to identify patterns in the literature in relation to the social values reported across structure type and stakeholder group. The concept of 'social value' is diffuse and highly context-specific, with many different approaches being taken to characterize and measure the values held by stakeholder groups. As a result, the literature identified in the review covered a range of different research areas, from stakeholder perceptions of MMI, to patterns of use, and links to social well-being. To gain an understanding of the priority research areas covered within the review, an inductive approach was adopted to identify the social research focus of the review papers. This involved analyzing the research focus of each of the papers classified as 2 or 3 stars, and slowly constructing dominant categories of research focus across the papers. Three overarching themes capturing the core research topics were identified, two containing subthemes (Figure 8):

- Social values
- Perceptions
- Use and satisfaction

In the next section, we summarise how social values were addressed in the literature, by structure type and stakeholder group, under each research theme.

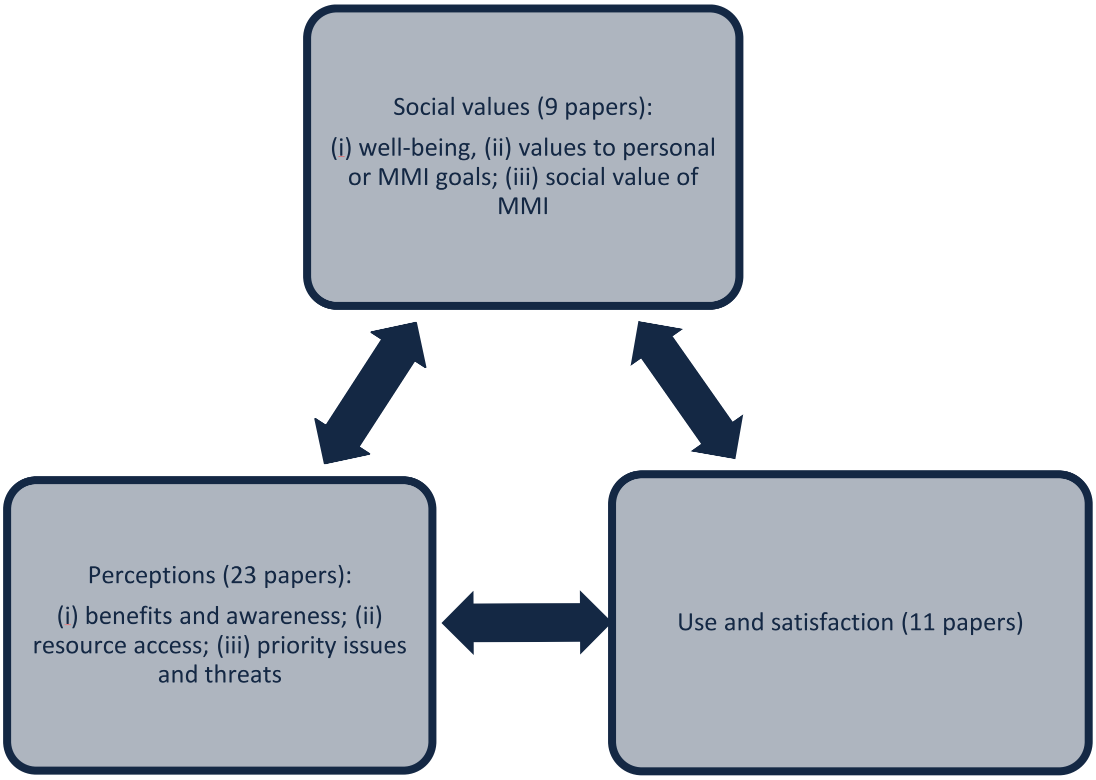

Figure 8: Research themes in the Social Values reviewed literature

Social Values

Nine papers identified in the review examined social values, as defined as 'a desirable goal based on what a person or group perceives as valuable and important that influences actions, behaviours, attitudes, and norms' (O'Connell et al., 2018). The nine papers were categorised into three subtopics on the basis of their focus on social value: (i) social well-being; (ii) interests and alignment to personal or MMI goals; (iii) and social value of the MMI resource/asset (Table 2). Each is described in turn.

Social Values: Well-being

The concept of well-being seeks to represent the elements that contribute to individual or community health, happiness and prosperity. A three-dimensional approach is adopted to explore values across three categories: material well-being (encompasses practical welfare and standards of living, such as income, wealth, assets, environmental quality, physical health), relational well-being (includes relations of love and care, networks of support and obligation, social, political and cultural identifies) and subjective well-being (spans notions of self, individual and shared hopes, fears and aspirations, expressed levels of satisfaction or dissatisfaction, trust, and confidence) (Weeratunge et al. 2014). The papers categorised under this sub-topic addressed different elements of well-being (e.g. material, relational or subjective). Only one paper addressed all three elements in unison (Barclay et al 2017); however, it did not incorporate MMI. It did however provide the most detailed assessment of social values of all papers captured in the systematic literature review. Note: The papers by Barclay et al (2017) and Voyer et al (2017) are based on the same research project, each reporting on different elements of the one project.

Social Values: Interests and alignment to personal or MMI goals

Under this theme, the focus of the research papers was on understanding the interests of different stakeholder groups and how these interests support or hinder the implementation of offshore MMI, to inform decision-making. In each case, the values of the stakeholder groups were not explicitly defined, rather the focus was on their interests, which were used to categorise stakeholders in different ways. For example, stakeholders were categorised based on their use of the MMI (e.g. primary/secondary users); or their interest in the MMI (e.g. community members, resource accessibility).

Social Values: Social value of the resource/asset

Under this topic, papers focused not on the social values of the stakeholder groups themselves, but rather on the social values derived from the 'resource' more broadly. For example, Pike et al (2010) obtained stakeholder perceptions of the social values of a Marine Protected Area, and therefore was not MMI focussed. Despite this, it provided an example of research seeking to understand the broader social values delivered by a resource and how these values are conceptualised across management groups. Evans et al (2017) addressed MMI, with the primary focus on obtaining stakeholder perceptions of the values (considerations and benefits) that determine whether MMI will be adopted. Pike et al (2010) can also be classed as addressing subjective well-being (i.e. what is perceived to be important), however the paper was separated here given the focus on the resource asset (what is important about the asset) rather than what was important to stakeholders.

Table 2: Literature addressing Social Values

Paper ID	Citation
Well-being	
#1	Barclay K., Voyer M., Mazur N., Payne A.M., Mauli S., Kinch J., Fabinyi M., Smith G. (2017) The importance of qualitative social research for effective fisheries management, *Fisheries Research*, 186: 426- 438
#24	Voyer, M., Barclay, K., McIlgorm, A., & Mazur, N. (2017) Connections or conflict? A social and economic analysis of the interconnections between the professional fishing industry, recreational fishing and marine tourism in coastal communities in NSW, Australia. *Marine Policy,* 76, 114-121
#23	R.L. Morris, G. Deavin, S.H. Donald, R.A. Coleman (2016) Eco-engineering in urbanised coastal systems: consideration of social values, *Ecol. Manag. Restor.* 17 (1) (2016) 33–39.
#17	Ramos, J; Santos, MN; Whitmarsh, D; Monteiro, CC (2006) The usefulness of the analytic hierarchy process for understanding reef diving choices: A case study, *Tourism Geographies,* 14(3): 361-382
Interests and alignment to personal or MMI goals	
#7	Ramos, J., Santos, M., Whitmarsh, D., & Monteiro, C. (2011b) Stakeholder analysis in the Portuguese artificial reef context: winners and losers, *Braz. J. Oceanogr*, 59: 133-143
#9	Schroeder D.M., Love M.S.(2004) Ecological and political issues surrounding decommissioning of offshore oil facilities in the Southern California Bight, *Ocean and Coastal Management*, 47: 21-48

P#13	Bates (2016) Key Challenges Of Offshore Wind Power: Three Essays Addressing Public Acceptance, Stakeholder Conflict, And Wildlife Impacts, PhD Thesis, Available online from: http://udspace.udel.edu/handle/19716/19780
Social value of the asset/structure	
#16	Pike, K., Johnson, D., Fletcher, S., Wright, P., & Lee, B (2010), Social Value of Marine and Coastal Protected Areas in England and Wales, *Coastal Management*, 38(4): 412 - 432
#21	A.J. Evans, B. Garrod, L.B. Firth, S.J. Hawkins, E.S. Morris-Webb, H. Goudge, P.J. Moore (2017) Stakeholder priorities for multi-functional coastal defence developments and steps to effective implementation, *Mar. Pol.* 75: 143–155.

Social Values: Type of structure and stakeholder groups

Despite the small number of papers dealing directly with social values, a range of types of MMI were covered in these publications, including artificial reefs, natural reefs, sea walls, offshore wind turbines and oil and gas infrastructure (Table 3). 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). These papers indicated that particular types of structures may be associated with values specific to stakeholder group, with divers valuing the diversity of species found in association with artificial reefs whilst recreational fishers' values were affected by the presence or absence of commercial fishers on natural reefs. Furthermore, the inter-dependence of stakeholder groups' values was influenced by less tangible factors such as the presence of a commercial fishing industry being positively associated with tourists' experience of a location.

Table 3 Coverage of MMI types and stakeholder groups for the Social Values literature

Sub-topic	**MMI type (PL)***	**Stakeholders****	**Examples**
Well-being (material, relational and subjective)	Artificial Reef: 1 Seawall: 1 Natural Reef: 1 None: 1	Artificial Reef: Divers Seawall: Not stated Natural Reef: Commercial fishermen, Recreational fishermen, Tourism sector None: Commercial and recreational fishing, tourism	Material: Despite a widespread perception among recreational fishers in NSW that recreational fishing catches are better if professional fishing is excluded, the data clearly showed that if professional fishing were to disappear from areas of the coast, the utility of recreational fishers would be negatively impacted (#1: Barclay et al. 2017) Subjective: Divers attach value to ecological diversity and conservation more than the chance to improve their diving skills (#17: Ramos et al. 2006). Relational: Tourists are drawn to communities because of seafood and activity brought in by commercial fishers (#24: Voyer et al. 2017).

Interests /values that align to the goals of the MMI or personal goals	Artificial Reef: 1 Oil and Gas: 1 Offshore Wind: 1 (1)	Artificial Reef: Commercial fishermen, recreational fishermen, tourism sector, government, scientists, ports, navy Oil and gas: None (lit review) Offshore Wind: Residents	Social/values concerns of stakeholders categorized into three groups: community membership, resource accessibility, environmental issues (#9: Schrouder and Love, 2004)
Social value of asset (e.g. global values associated with MMI)	Coastal defense structures: 1 None (Marine Protected Area): 1	Coastal defense structures: Infra specialists, government, environmental groups None (MPA): MPA experts/managers;	Industry managers perceive the ecological value of the environment as more important more than spirituality and organisational interest (#16: Pike et al. 2010)

* Brackets indicated the number of professional reports in total value
** Brackets indicate the number of papers/reports incorporating the stakeholder group

Perceptions

The subjective values held by individuals will shape their expressions of opinion or 'perceptions' in relation to external objects. Perceptions in relation to MMI are thus informed by individual values but may be easier to identify and quantify than values, and consequently recur far more frequently in the literature review. We classified research into perceptions of MMI into three subcategories, namely (i) stakeholder perceptions in general (social and environmental benefits, awareness levels, perceptions of conflict); (ii) resource access (to the area and the items within the area, i.e. fish); (iii) priority issues/threats associated with MMI.

Perceptions: General perceptions

Whilst there were a relatively large number of academic and professional publications examining the overall perceptions and perceived benefits of MMI from a variety of study locations worldwide, the majority of these pertained to either artificial reefs or offshore wind turbines. The latter have been the focus of research in the past 2-3 years, reflecting the growth of the offshore wind energy sector particularly in the United Kingdom.

Perceptions: Resource access

The literature regarding perceptions of resource access to MMI is more restricted, but does encompass research particularly focusing on repurposing of offshore oil and gas infrastructure in Australia and the USA.

Perceptions: Priority issues/threats

The literature on priority issues and threats predominantly incorporates professional rather than academic literature. The reports seek to understand stakeholders' views on the priority concerns in relation to repurposing of offshore oil and gas facilities or the installation of artificial reefs.

Table 4: Literature addressing Perceptions

Paper ID	Citation
Perceptions in general (social and environmental benefits, awareness levels, perceptions of conflict)	
#5	Murray, J. D., & Betz, C. J. (1994) User views of artificial reef management in the southeastern US, *Bulletin of Marine Science*, 55: 970 - 981

#6	Ramos, Jorge; Santos, Miguel N.; Whitmarsh, David; Monteiro, Carlos C. (2007) Stakeholder perceptions regarding the environmental and socio-economic impacts of the Algarve artificial reefs, *Hydrobiologia,* 580: 181 - 191
#8	ten Brink T.S., Dalton T. (2018) Perceptions of commercial and recreational fishers on the potential ecological impacts of the Block Island Wind Farm (US), *Frontiers in Marine Science,* 5: 439
#11	Andriesse E. (2018) Persistent fishing amidst depletion, environmental and socio-economic vulnerability in Iloilo Province, the Philippines, *Ocean and Coastal Management*, 157: 130- 137
#12	Hooper T., Ashley M., Austen M. (2015) Perceptions of fishers and developers on the co-location of offshore wind farms and decapod fisheries in the UK, *Marine Policy*, 61: 16- 22
#13	Hooper T., Hattam C., Austen M. (2017) Recreational use of offshore wind farms: Experiences and opinions of sea anglers in the UK, *Marine Policy*, 78: 55-60
#14	Kienker, S. E., Coleman, R. A., Morris, R. L., Steinberg, P., Bollard, B., Jarvis, R., . . . Strain, E. M. A. (2018), Bringing harbours alive: Assessing the importance of eco-engineered coastal infrastructure for different stakeholders and cities, *Marine Policy,* 94: 238 - 246
#15	Lima J.S., Zappes C.A., Di Beneditto A.P.M., Zalmon I.R. (2018), Artisanal fisheries and artificial reefs on the southeast coast of Brazil: Contributions to research and management, *Ocean and Coastal Management*,163: 372-382
#18	Shani A., Polak O., Shashar N. (2012) Artificial Reefs and Mass Marine Ecotourism, *Tourism Geographies,* 14 (3): 361-382
#20	Tessier A., Francour P., Charbonnel E., Dalias N., Bodilis P., Seaman W., Lenfant P. (2015), Assessment of French artificial reefs: due to limitations of research, trends may be misleading, Hydrobiologia, 753 (1)
#22	Ditton, R.B., Osburn, H.R., Baker, T.L. and Thailing, C.E. (2002) Demographics, attitudes, and reef management practices of sport divers in offshore Texas waters. *ICES Journal of Marine Science* 59, 186–191.
P#13	Bates (2016) Key Challenges Of Offshore Wind Power: Three Essays Addressing Public Acceptance, Stakeholder Conflict, And Wildlife Impacts, PhD Thesis, Available online from: http://udspace.udel.edu/handle/19716/19780
P#3	CRC Research Centre (1999) Understanding public perceptions of the Great Barrier Reef and its management, Available online from: http://rrrc.org.au/wp-content/uploads/2014/03/Technical-Report-29.pdf
P#11	Leeworthy, Wiley and Hospital (2004) Importance-Satisfaction Ratings Five-year Comparison, SPA & ER Use, and Socioeconomic and Ecological Monitoring Comparison of Results 1995-96 to 2000-01, Available online from: https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/archive/science/socioeconomic/floridakeys/pdfs/impsat.pdf
Resource Access	
#4	Kruse S.A., Bernstein B., Scholz A.J. (2015) Considerations in evaluating potential socioeconomic impacts of offshore platform decommissioning in California, *Integrated Environmental Assessment and Management*, 11 (4): 572-583
#10	Ammar, M. S. A. (2009) Coral Reef Restoration and Artificial Reef Management, Future and Economic, *Open Environmental Engineering Journal*, 2 (1): 37-49
#12	Hooper T., Ashley M., Austen M. (2015) Perceptions of fishers and developers on the co-location of offshore wind farms and decapod fisheries in the UK, *Marine Policy*, 61: 16- 22
#19	Sutton S.G., Bushnell S.L. (2007) Socio-economic aspects of artificial reefs: Considerations for the Great Barrier Reef Marine Park, *Ocean and Coastal Management,* 50(10): 829-846
P#1	Shaw J.L., Seares P., Newman S.J. (2018) Decommissioning offshore infrastructure: a review of stakeholder views and science priorities, Available online from: http://www.marinescienceblueprint.org.au/
P#2	WAFIC (2017) Thevenard Offshore Platform Retirement Commercial Fishing Sector Stakeholder Consultation – WAFIC Report. Available from: https://www.wafic.org.au/offshore-stakeholder-consultation-environment-plans-nopsema-update-commercial-fishers/
Priority Issues/threats associated with MMI	
#26	Cripps SJ and Aable JP (2002), Environmental and socio-economic impact assessment of Ekoreef, a multiple platform rigs-to-reef development, *Journal of Marine Science*, 59: 300-308.
P#1	As above
P#2	As above

P#11	Leeworthy, Wiley and Hospital (2004) Importance-Satisfaction Ratings Five-year Comparison, SPA & ER Use, and Socioeconomic and Ecological Monitoring Comparison of Results 1995-96 to 2000-01

Perceptions: Type of structure and stakeholder groups

Artificial reefs have been the principal focus of research into perceptions of MMI, with studies demonstrating that stakeholder groups can hold markedly different views on the environmental benefits of artificial reefs whilst also highlighting the issues surrounding access rights to newly installed offshore infrastructure. However, both studies used as examples in Table 5 are somewhat dated now and may not reflect contemporary perspectives given the increased availability of scientific data relating to biomass around artificial reefs and greater management experience.

Table 5 Coverage of MMI types and stakeholder groups for the Perceptions literature

Sub-topic	**MMI type (PL)***	**Stakeholders****	**Examples**
Perceptions in general (social and environmental benefits, awareness levels, perceptions of conflict)	Artificial Reef: 8 (1); Offshore Wind: 3 (1) Seawall: 1 Natural Reef: 1 (1);	Artificial Reef: Commercial fishing (5), Recreational Fishing (3), Divers (5), Recreational boaters (1), Environmentalists (2), Local government (1), Research (1), Tourists (1), Residents (1) Offshore wind: Residents (1), Commercial fishing (2), Recreational fishing (2) Seawall: Harbour workers, local businesses, tourists/recreationalists (1) Natural reef: None (1)	Scientists have more optimistic perceptions of the impact of artificial reefs on the environment whereas fishers reported more sceptical views (#6: Ramos et al. 2007)
Resource access (to the area and the items within the area, i.e. fish)	Artificial Reef: 2 Oil and Gas: 3 (2) Wind: 1	Artificial Reef: Commercial fishing (1), Recreational fishing (1), Divers(1), Management authorities (1), Research (1), Industry (1), Community (1), Local Business (1), None (lit review) (1) Oil and Gas: Commercial fishing (3), Recreational fishing (2), Divers(2), Recreational boating (1), Commercial shipping (1), Management authorities (1), Research (1), Private industry (aquatic) (1), Community groups (1) Offshore Wind: Commercial fishermen (1), Private business(1)	Placing an artificial reef in an area where commercial fishers operate can exclude them from an area that was formally open access and their perceived 'right' to use (#19: Sutton & Bushnell, 2007)
Priority issues/threats associated with MMI	Artificial Reef = 1 (1) Oil and gas = 3 (2)	AR: Recreational and commercial fishing, diving, fisheries agencies, researchers, the aquatic industry, community groups O&G: Commercial fishers (1); Rec boaters, tourists, residents (1); None (1)	Destruction and or disruption of the benthic environment is a major concern, as too is the potential impact of structures left below on vessels (#P2: WAFIC, 2017)

* Brackets indicated the number of professional reports in total value
** Brackets indicate the number of papers/reports incorporating the stakeholder group

Use and Satisfaction

The final category incorporated papers exploring the use of, and satisfaction with, MMI (Table 6). The predominant focus was 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) (Table 7). Information ranged from examining the types of dive activities underway (Ditton et al 2002), to preferences for different forms of artificial reef (e.g. Sahni et al 2012) and marine environments (e.g. natural versus artificial, Belhassen et al 2017; habitat preferences, Kirkbride-Smith et al 2013). Kirkbride-Smith et al 2013 found that shipwrecks were the most preferred form of artificial reef (76%), followed by sunken vessels (15%) and piers, jetties or platforms (3%).

Table 6: Literature addressing Use and Satisfaction

Paper ID	Citation
#2	Belhassen, Y., Rousseau, M., Tynyakov, J., & Shashar, N (2017) Evaluating the attractiveness and effectiveness of artificial coral reefs as a recreational ecosystem service, Journal of Environmental Management, 203 (1): 448 - 456
#3	Kirkbride-Smith A.E., Wheeler P.M., Johnson M.L. (2013) The Relationship between Diver Experience Levels and Perceptions of Attractiveness of Artificial Reefs - Examination of a Potential Management Tool, *PLoS ONE*, 8(7)
#5	Murray, J. D., & Betz, C. J. (1994) User views of artificial reef management in the southeastern US, *Bulletin of Marine Science*, 55: 970 - 981
#8	ten Brink T.S., Dalton T. (2018) Perceptions of commercial and recreational fishers on the potential ecological impacts of the Block Island Wind Farm (US), Frontiers in Marine Science, 5: 439
#18	Shani A., Polak O., Shashar N. (2012) Artificial Reefs and Mass Marine Ecotourism, *Tourism Geographies,* 14 (3): 361-382
#20	Tessier A., Francour P., Charbonnel E., Dalias N., Bodilis P., Seaman W., Lenfant P. (2015), Assessment of French artificial reefs: due to limitations of research, trends may be misleading, Hydrobiologia, 753 (1)
#22	Ditton, R.B., Osburn, H.R., Baker, T.L. and Thailing, C.E. (2002) Demographics, attitudes, and reef management practices of sport divers in offshore Texas waters. ICES Journal of Marine Science 59, 186–191.
#25	Stolk P., Markwell K., Jenkins J.M. (2007) Artificial reefs as recreational scuba diving resources: A critical review of research, Journal of Sustainable Tourism, 15(4): 331- 350
P#3	CRC Research Centre (1999) Understanding public perceptions of the Great Barrier Reef and its management, Available online from: http://rrrc.org.au/wp-content/uploads/2014/03/Technical-Report-29.pdf
P#4	CRC Reef Research Centre (1998), Visitor experiences and perceived conditions on day trips to the Great Barrier Reef, Available from: http://rrrc.org.au/wp-content/uploads/2014/03/Technical-Report-21.pdf
P#12	Montes, N., Sidman, C., Lorenzen, K., Tamura, M. and Ishida, M., (2019) Influence of fish aggregating devices on the livelihood assets of artisanal fishers in the Caribbean, *Ocean & Coastal Management*, 179: 104823.

Use and Satisfaction: **Type of structure and stakeholder groups**

As per the Perceptions literature, artificial reefs were again the principle MMI type of focus for research on stakeholder use and satisfaction. Seven of the eight papers assigned to this theme engaged recreational divers, and in four of these papers, divers were the only stakeholder group engaged. The outlying paper examined the past and current uses of offshore wind turbines by commercial and recreational fishermen (ten Brink and Dalton 2018), comparing past and current uses and perceptions of change before and after wind turbines were constructed and operational (e.g. ecological and behavioural impacts).

Table 7 Coverage of MMI types and stakeholder groups for the Use and Satisfaction literature

Sub-topic	MMI Type (PL)*	Stakeholders**	Examples
Use levels, preferred resources/environment for activity (e.g. natural versus artificial reefs), satisfaction level with asset	Artificial Reef: 7 Offshore Wind: 1 Moored FAD: 1 (1) Natural Reef: 2 (2)	Artificial Reef: Divers (7), Commercial fishing (2), Recreational fishing (2), Environmentalists (1) Offshore Wind: Commercial fishing, Recreational fishing Moored FAD: Artisanal fishers Natural Reef: Tourists (1), None (1)	Divers use a mixture of natural and artificial reefs. Though they feel more relaxed when diving in a natural environment the artificial sites were reported as more popular (#2: Belhassen et al. 2017)

* Brackets indicated the number of professional reports in total value
** Brackets indicate the number of papers/reports incorporating the stakeholder group

Table 8: Literature coverage of social research themes, by stakeholder group and MMI type

	Stakeholder Group	Commercial fishing					Recreational Fishing					Diving					Other*					None/Not stated						
	MMI Type	AR	O&G	Wind	Other*	None	AR	O&G	Wind	Other	None	AR	O&G	Wind	Other	None	AR	O&G	Wind	Other	None	AR	O&G	Wind	Other	None	TI**	TD***
Social values	Personal				1	1				1	1	1							1	1		1	2				10	6
	Global	1					1										1			2							5	3
Perceptions	Benefits /awareness	4		2			3		1			5					3		1	1					1		21	13
	Priority issues/threats		2				1	1				1	1				2	1					1				10	4
	Resource access	1	3	1			1	2				1	2				1	2	1			1					16	6
Use types and satisfaction		3		1			3		1			5					1			1					1		16	11
	Total Instances	9	5	4	1	1	9	3	2	1	1	13	3	0	0	0	8	3	3	5	0	2	2	0	2	0		

* 'Other' includes all other stakeholder groups, for example, residents, local government, researchers; and 'Other' MMI types, for example, seawalls, coastal defence and eco-engineering

**Total number of instances that the stakeholder group or MMI type was covered across the reviewed literature

*** Total number of reports/documents from the reviewed literature addressing the selected subcategory.

Summary

At the completion of the social values literature review, it was clear that while there is significant advocacy for research examining social values to support effective decision-making in marine environments, the available research addressing this topic for MMI is limited. Artificial reefs and the diving sector dominate the literature (Table 8). Stakeholder perceptions of the benefits and awareness of MMI is also the primary research focus, followed by the use types, satisfaction with, and access to MMI. Social values are rarely explored and when done so, only for select elements of social value (e.g. relational aspects or subjective aspects in isolation).

Despite this, the studies identified in the systematic review cover select structure types, stakeholder groups, and aspects of social value. Therefore, by bringing together the information from across the review, a model of social values for MMI could be constructed (Figure 9). The elements within the constructed model (i.e. material, subjective and relational values across multiple scales) closely align to the social well-being framing, which has been advocated as an approach to integrate social, economic and environmental aspects in fisheries management (see for example Weetatunge et al. 2014). Consequently, the established, peer-reviewed representation of social values, adopting the well-being lens as reported in Weeratunge et al (2014) was modified for an MMI context and established as the conceptual model supporting the ongoing research (Figure 10).

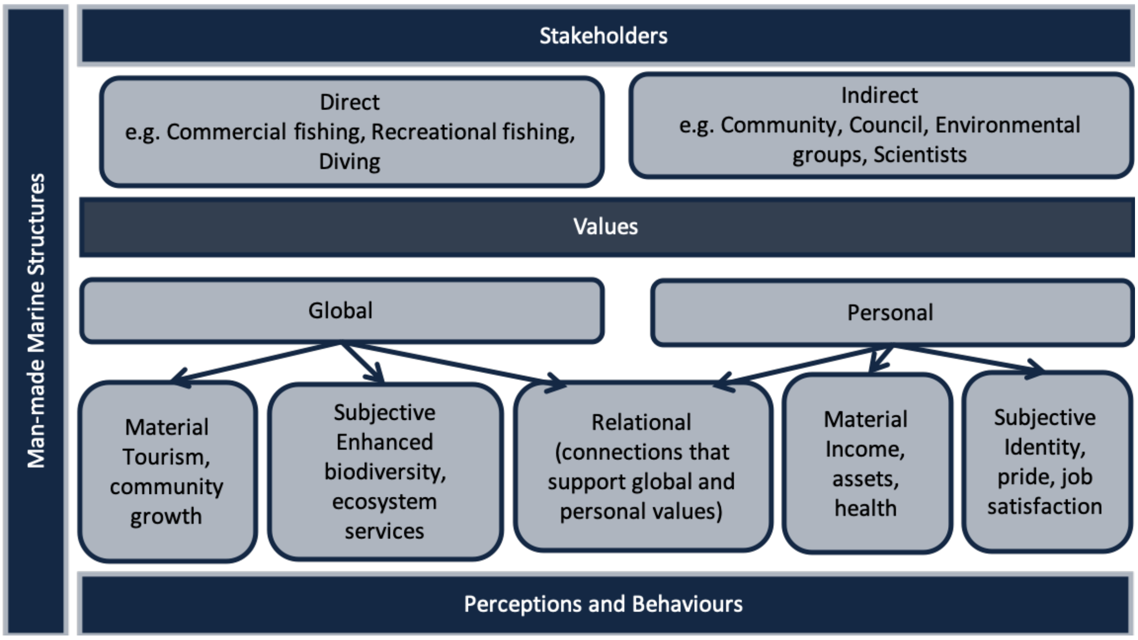

Figure 9: Preliminary conceptual model of social values for MMI

Micro-scale

Material

- Income associated with activity
- Catch quantity associated with activity
- Rights of access to location of activity

Subjective

- Independence to conduct activity
- Wellbeing associated with conduct of activity
- Experience of activity
- Satisfaction with catch arising from activity
- Importance of memories/souvenirs from activity

Relational

- Outcomes of interactions via social networks (family, friends, community, fellow users) as a result of activity

Meso-scale

Material

- Outcomes for tourism sector in community
- Diversification of employment opportunities in community

Subjective

- Ecological connectivity between aquatic manmade infrastructure
- Inter-generational consequences of presence of aquatic manmade infrastructure

Relational

- Conflict or co-operation between sectors of community
- Cultural significance of aquatic manmade infrastructure

Macro-scale

Subjective/Material

- Ecosystem health in relation to presence of aquatic manmade infrastructure

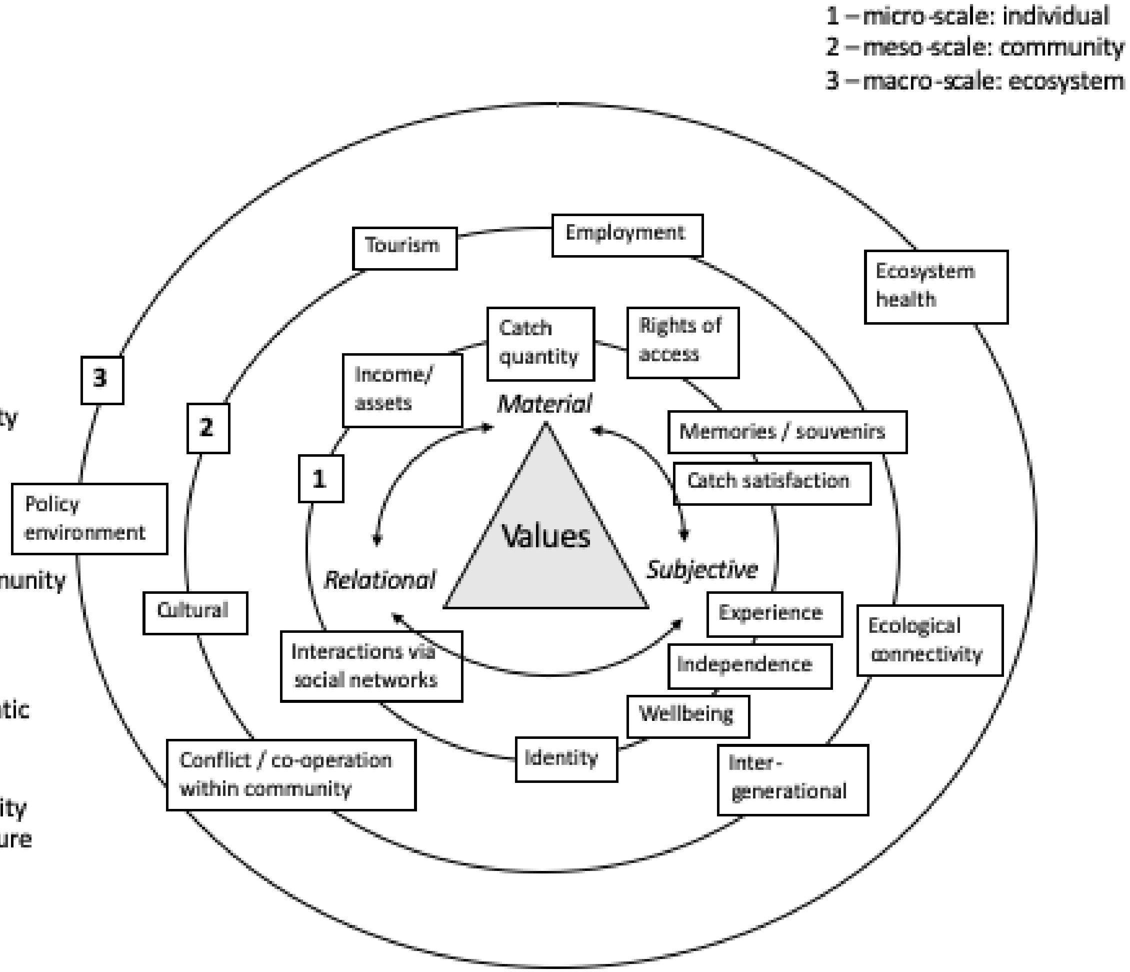

Figure 10: Conceptual model of the social values of man-made marine structures, following Weeratunge et al (2014)

Economic Value Findings

The systematic literature research found 34 studies that quantified the economic value that MMI provide to stakeholders such as divers (20), recreational fishers (10), commercial fisheries (7), the general public (3) and other user groups (7). Since the first study on the economic value of a marine artificial structure was published in 1973 by Buchanan, the number of publications on this topic has steadily increased and the issue has started to gain considerably more attention in the last 2 decades (Figure 11). One study was published in the 1970s, three in the 1980s, three in the 1990s, 14 in the 2000s, and 14 in the 2010s (please note that this number is still subject to changes until the end of 2019). While the literature indicated economic values from artificial reefs all over the world, nearly half of these studies (17) were conducted in the USA and much less in other parts of the world. There are six European studies (2 in Portugal, 3 in the UK, 1 in France); five Asian studies (2 in India, 1 in Malaysia, 1 in Taiwan); two Middle-Eastern studies (Israel); two Central/South American studies (Brazil and Barbados), one African study (Kenya); and one Oceanian study (Australia).

All articles quantified direct use values, whereas non-use values were assessed by only two studies. To our knowledge, no study has estimated indirect use values, even where studies had a context that could be relevant (e.g. coastal protection). The reason for this is probably that different value types can overlap. For example, if one wants to measure the total economic value of an artificial reef and estimates the direct use value provided by an increased catch rate of fish due to habitat enhancement it would be double counting to measure the value of habitat enhancement that causes the increased catch rate (unless there are other economic benefits associated with the habitat enhancement that are not included in the direct use value of the catch). Due to the lack of indirect use values in the literature, this value type is not further discussed in the following sections.

The following sections review the economic values for each of the MMI types as well as the potential applicability to the case studies following the TEV framework.

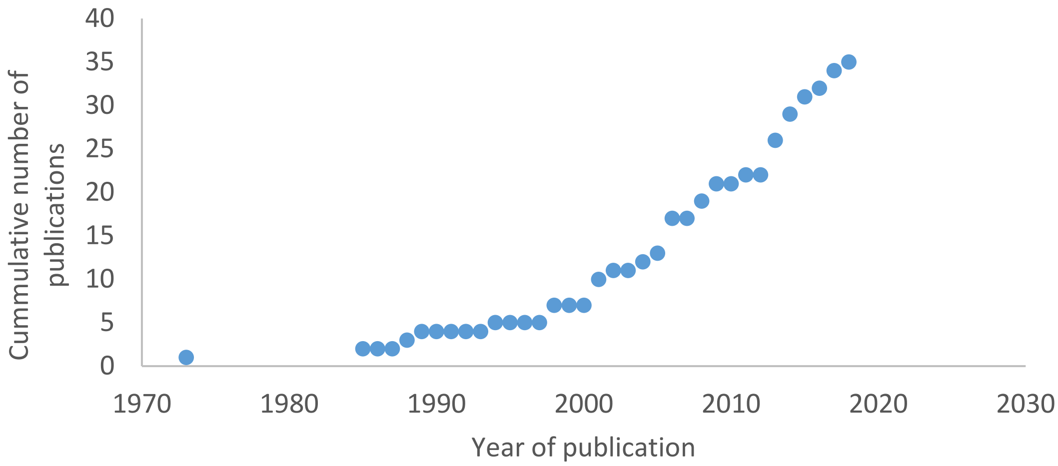

Figure 11: Cumulative number of economic valuation studies on marine man-made structures.

Artificial reefs

Direct-use values

Artificial reefs have been found to generate direct use values in terms of business revenues from extractive uses such as commercial fishing (Vivekanandan et al., 2006, Brock, 1994, Islam et al., 2014) and recreational fishing (Buchanan 1973; Milon 1989; 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. Moreover, 16% of recreational fishers stated that they would not return to the area if the artificial reef was not there. They argue that therefore the revenues of these fishers would be lost without that reef. In Brazil, an artificial reef was deployed to protect the habitat from trawling activities which positively influenced recreational fishing and dive tourism in the area (Brandini 2014).

In addition to revenues from extractive activities, artificial reefs also have been found to provide economic benefits to non-extractive uses such as scuba diving (Chen et al. 2013; Ditton et al. 2001; Dowling & Nichol 2001; Leeworthy et al. 2006; Westerberg et al. 2013; Wilhelmsson et al. 1998), snorkelling, surfing, and boat tours (Pendleton 2005; V Westerberg et al. 2013). 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. Similarly, Ditton et al. (2001) estimated the expenditures from scuba divers on artificial reefs in Texas to be between USD 320,324 and 960,712 per year and a shipwreck in Florida, USA increased total recreational expenditures from snorkelers, divers and boating by USD 2.7 million (Leeworthy et al. 2006).

Artificial reefs not only directly enhance habitat but also 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 harm natural reefs. Hannak et al. (2011) did a contingent valuation study and found that especially the less experienced snorkelers (who are more likely to damage reefs) were willing to pay for the snorkel trail and an educational training to protect natural reefs.

Some valuation studies on marine artificial structures include economic impact assessments (Bell et al. 1998, Johns et al. 2001). Economic impact assessments quantify the increased economic activity that e.g. the deployment of an artificial reef brings to a region. This is typically measured as the number of jobs and the income the artificial reef is generating. For example, Johns et al. (2001) estimated that artificial reefs in Southeast Florida provide 26,800 jobs and are generating USD 2.4 billion of revenues annually. A similar study from Bell et al. (1998) used the contingent valuation method and showed that artificial reefs in Northwest Florida have an annual impact of USD 415 million annually and provide 8,100 jobs.

Two articles compare economic values of commercial fishing opposed to recreational and/or tourism activities on artificial reefs in Hawaii (Brock 1994), and Kenya (Crabbe and McClanahan, 2006). Both studies found that the revenues generated from recreation and tourism exceed those from commercial fishing by far.

Finally, the controlled position of artificial reefs allow for safer conditions than on some natural sites. Christie (2009) assessed the economic value associated with (among other attributes) safer swimming conditions and found that all members of a community in Wales held significant values for a multipurpose reef which would provide such conditions. Likewise, Taiwan residents were willing to pay about USD 13 per recreational fishing and diving trip for access to an artificial reef zone that provides safer conditions than surrounding areas (Chen et al. 2013).

Non-use values

Non-use values result from peoples' satisfaction which a natural resource provides that is not traded in a market. This satisfaction can have various sources. For example, as described above, artificial structures in the ocean have the ability to enhance marine habitat and therefore improve the biodiversity and/or abundance of marine life on and around them. Although there is no process by which these values can be captured by any party, techniques exist that quantify them in monetary form. Hence, people who value these natural benefits can have a "willingness to pay" for maintaining artificial structures. We have found two articles that measured non-use values of artificial reefs. Börger et al. (n.d.) used a discrete choice experiment to estimate the willingness to pay of residents in Ireland for an increase in biodiversity on an offshore windfarm off the coast of Ireland. They found that people were willing to pay GBP 7.25 and GBP 14.83 per person for an increase of ten and 30 species settling on the windfarm, respectively. Hicks et al. 2004 conducted a contingent valuation study to measure the public's willingness to pay for artificial oyster reef programs. Their results show that the general public have a positive attitude towards oyster reef restoration programs, and are willing to pay a median of USD 86.68 per year in income taxes to fund oyster reef programs although they not necessarily use such reefs.

Artificial reefs versus natural reefs

A total of nine studies have compared economic values related to artificial reefs with those from non-artificial reef sites. Three studies have found that revenues from commercial fishing were significantly higher on artificial reefs than on adjacent areas. Kasim et al (2013) found that the revenues of commercial fishers in India were over twice as high on artificial reefs compared to non-artificial reef areas and Vivekanandan et al. (2006) estimated the income from hook and line fishing on artificial reefs to be 36% higher than on non-artificial reef sites. Similarly, results from (Whitmarsh et al. 2008) show that the revenues from an artisanal fishery on an artificial reef off the Algarve in Portugal to be substantially higher than on control sites. However, the literature also indicates that this is not always the case. For example, the monthly fishing income from artisanal fishers on an artificial reef in Malaysia was lower than on adjacent natural reefs (Islam et al. 2014) and Crabbe and McClanahan (2006) observed that not all commercial fisheries benefited from deployed shipwrecks in Kenya resulting in potential stakeholder conflicts.

Another set of four articles estimated the willingness to pay for recreational activities on artificial reefs and natural reefs (or other adjacent natural sites). Overall, the majority of these studies (three out of four) indicate that people have a higher willingness to pay for natural reefs than for artificial reefs. In Southeast Florida, Johns et al. (2003) observed that recreational reef users (including recreational fishers, reef divers, reef snorkelers, and visitors viewing the reefs on glass-bottomed boats) were willing to pay an extra $12.74 per person per day in trip costs to maintain artificial reefs in their existing condition. The comparative value for natural reefs was significantly higher, at $18.81 per person per day. When these values were aggregated over the population, their results showed a willingness to pay to protect natural reefs (USD 229.3 million/year) over double as high as to protect artificial reefs (USD 85.1 million/year) (Johns et al., 2003). Similarly, (Oh et al. 2008) estimated that values over the annual trip expenditures from divers in Texas were $159.97 per person for artificial reefs and $270.83 per person for natural reefs. Also, (although not statistically significant) marine park users in Barbados were willing to pay an additional $19.18 per day in trip costs to recreate at artificial reefs, compared to $20.00 per day for natural reefs (Kirkbride-Smith et al. 2013). On the other hand, Huth et al. (2015) conducted a contingent behaviour study and found that dive tourists in Florida had higher willingness to pay for a dive trip to a shipwreck (USD 368) than to natural reefs (USD 300). All literature on the economic value of artificial reefs is shown in Table 9.

Exmouth Integrated Artificial Reef

The Exmouth Integrated Artificial Reef (EIAR or also called the King reef) was deployed in July 2018 with the purpose to enhance habitat to benefit the environment as well as to provide a new, accessible and safe recreational fishing site in Exmouth, Western Australia. We have identified the following economic values that can be associated with the deployment of the EIAR if these objectives are met.

Direct-use values

- *Expenditures:* The EIAR can provide extractive direct use-values through recreational fishing activities. The direct economic impact associated with the development of the reef includes direct expenditure from recreational fishers (e.g. on boat fuel and fishing gear) in pursuing activities on the EIAR. Moreover, a boat ramp survey from Recfishwest has shown that the EIAR is also visited by divers and snorkelers. Therefore, expenditures from divers that visit the EIAR account for non-extractive direct use-values.

  The EIAR is well accessible, about 6.5 km distance from the Exmouth marina and 9.6 km from the Bundegi boat ramp. Hence, visitors to the region might be able to benefit from the EIAR by reducing the resources that are necessary to invest (e.g. in fuel costs and time) to reach the EIAR compared to substitute sites with a similar experiential quality.

- *Multiplier effects:* In addition to this direct economic impact, there are multiplier effects which arise when local businesses that supply goods and services to recreational fishers and divers in turn demand goods and services from their suppliers. Consequently, these shops spend money for e.g. on rent, electricity, fuel and materials. This generates output, incomes and employment in those industries supplying the local businesses and shows how the wider economy might benefit from the EIAR.

- *Consumer surplus:* In addition to the expenditures, recreational fishers and divers will derive a value that is over and above the cost incurred to participate in the EIAR related activity. This consumer surplus can be increased if the EIAR can provide a more enjoyable experience. An improved fishing experience could result from an increased fish abundance and diversity which in turn could enhance the catchability and catch rate on the EIAR. Accordingly, divers might have an improved experience when they observe a more diverse and abundant habitat. Moreover, recreational fishing on the nearby natural Ningaloo reef is limited due to rough weather conditions. Hence, the EIAR was positioned inside the Exmouth Gulf where weather conditions are more stable. This can increase visitors' consumer surplus through safer conditions on the water.

Indirect use-values

In addition to the direct use-values, the EIAR can potentially provide indirect use values due to spill-over effects. Spill-over effects occur when fish and other fauna are over-produced in one area and move into nearby areas. Where commercially important species spill-over into fishing grounds, the EIAR might indirectly increase the profitability of commercial fisheries.

Non-use values

An ecological monitoring program has shown increased fish abundance and diversity on the EIAR in comparison to the same area before the deployment as well as compared to adjacent habitats (Harvey et al., unpublished data). It is reasonable to expect that residents of Western Australia would have some positive willingness to improve fish abundance and biodiversity in the Exmouth Gulf. Conversely, it is possible that other members of the general public value habitats that are undisturbed from human intervention. In that case, the EIAR would have reduced the value this area provides for them.

Generally, it is important to notice that there is a debate about the level that artificial reefs are able to produce marine fauna as opposed to attracting it from adjacent areas. Therefore, it remains unclear whether (or to what extent) the EIAR can provide the economic benefits that depend on increased productivity. Also, while the preliminary ecological surveys have shown increased fish abundance and diversity, the EIAR is still in its early stages and will not have reached an equilibrium, which may be a higher level of productivity than currently seen. However, countering that, the fishing pressure will also not yet be at equilibrium, and one would expect that will provide a counterweight that will reduce fish populations. Therefore, economic surveys with stakeholder groups and long-term ecological monitoring of the EIAR would be necessary to understand the economic values associated with the EIAR.

Table 9: Economic valuation studies on artificial reefs (n=29).

Study	AR[1] Type(s)	Value Type(s)	Data Collection Year	Valuation Method(s)	Country	Valuation Context/Description	WTP (study units)	WTP (2019 USD)
Bell et al. 1998	Shipwreck	Use – Direct (Recreation/Tourism)	1997-1998	Market Non-market (CVM[2])	USA	Revenues from user expenditures Consumer surplus for residents and tourists	$414 million/study period $3.62-$4.4/$6.51-$7.96 per day and resident/visitor	652 million/study period $5.7-$6.93/$10.25-$12.54 per day and resident/visitor
Börger et al. (2015)	Wind Turbines	Non-use (Existence) Use – Direct (Visual Amenity)	2013	Non-Market (DCE[3])	UK	Hypothetical windfarm in the Irish Sea between Anglesey and the Isle of Man <u>Attributes/levels</u>: 0, 10, 30 additional species to settle in and around the new offshore wind farm 180m, 240m, 300m high turbines No impact (cabling buried at 1m) Impact on marine mammals (cabling buried at 2m) <u>Payment vehicle</u>: additional tax to be paid annually by every household to fund alternative windfarm design	£7.25-£12.91 per household per year (10 species) £14.83-£15.84 per household per year (30 species) No impact of wind turbine height/visibility on WTP £26.49 per household per year to prevent impact of cables on marine mammals	$10.79-$19.21 per household per year (10 species) $22.06-$23.56 per household per year (30 species) No impact of wind turbine height/visibility on WTP $30.11 per household per year to prevent impact of cables on marine mammals
Brandini et al. 2014	Concrete structures	Use – Direct (Recreation/Tourism)	1998-2003	Market	Brazil	Revenues from recreational fishing and dive tourism	$266,000/$69,400 revenues from recreational fishing/dive tourism in study period	$288,498/$75,270 revenues from recreational fishing/dive tourism in study period
Brock et al. 1994	Various sunken objects (ship, concrete modules, aircraft)	Use – Direct (Recreation/Tourism, Commercial Fishing)	1990	Market	USA	Revenue associated with submarine/dive tourism and commercial fishing on Hawaiian ARs	$69.63/$63.02 pp per submarine tour/dive $58,840 per year for commercial fishing (4% of net profit of dive tourism alone)	$135.43/$122.57 pp per submarine tour/dive $114,440 per year for commercial fishing
Buchanan 1973	Car tyres and sunken ships	Use- Direct	1972	Market	USA	Total expenditure associated with AR	$36,000 per 4 months season	$221,132 per 4 months season

Study	AR[1] Type(s)	Value Type(s)	Data Collection Year	Valuation Method(s)	Country	Valuation Context/Description	WTP (study units)	WTP (2019 USD)
Chen et al. 2013	Various sunken objects (ships, utility poles, steel and concrete structures)	Use – Direct (Recreation/Tourism)	2008	Non-Market (TCM[4] and CVM)	Taiwan	Travel costs associated with diving/recreational fishing trips in Penghu Survey question: *"How much did you actually pay (travel and other costs) to participate in scuba diving or recreational boat fishing?"* WTP for a ticket to visit an AR diving/recreational fishing zone in Penghu Survey question: *"If the government planned an AR scuba diving zone (or boat fishing zone) to improve the safety and facilities and to provide ocean weather conditions and other recreation information, how much would you be willing to pay for a ticket to participate in these activities?"*	\$348.50/\$281.91 per tourist per trip for diving/recreational fishing (TCM) \$12.70/\$13.00 per ticket for diving/recreational fishing (CVM)	\$\$411.46/\$332.83 per tourist per trip for diving/recreational fishing (TCM) \$14.99/\$15.35 per ticket for diving/recreational fishing (CVM)
Christie et al. 2009	Sunken Sandbags (TerraFix mega geotextile)	Use – Direct (Visual Amenity, Recreation/Tourism)	(not stated)	Non-Market (DCE)	UK	Coastal defence options for Borth in West Wales Attribute levels: no change (timber groynes), rock groynes, offshore reef Payment vehicle: annual increases in local tax over a five-year period	£98 per household per year (offshore reef excl. improved surf conditions) £171 per household per year (offshore reef incl. improved surf conditions)	\$171 per household per year (offshore reef excl. improved surf conditions) \$298 per household per year (offshore reef incl. improved surf conditions)
Crabbe & McClanahan 2006	Sunken Ships	Use – Direct (Recreation/Tourism, Commercial Fishing)	2004	Market	Kenya	Revenue associated with commercial fishing and dive tourism	\$9.00 increase per fisher per day at landing site for commercial fishing \$75,000-\$174000 per wreck per year in dive tourism	\$12.00 increase per fisher per day at one landing site for commercial fishing \$100,927-\$234.151 per wreck per year in dive tourism

Study	AR[1] Type(s)	Value Type(s)	Data Collection Year	Valuation Method(s)	Country	Valuation Context/Description	WTP (study units)	WTP (2019 USD)
Ditton et al. (2001)	Various sunken objects (man-made materials, shipwrecks, oil and gas platforms)	Use – Direct (Recreation/Tourism)	1997	Market	USA	Revenue associated with commercial dive tourism	$162 pp per diving trip day for Texas residents $170 pp per diving trip day for Texas non-residents	$256.58 pp per diving trip day for Texas residents $270.67 pp per diving trip day for Texas residents
Dowling and Nichol (2001)	Sunken Ships	Use – Direct (Recreation/Tourism)	1999	Market	Australia	Revenue associated with commercial diver tourism and recreational fishing	$22.20 pp per day for private permit divers $35.35 pp per day for domestic group charter divers $41.10 pp per day for international group charter divers	$33.87 pp per day for private permit divers $53.94 pp per day for domestic group charter divers $62.71 pp per day for international group charter divers
Hannak et al. 2011	Snorkel trail	Use – Direct (Recreation/Tourism)	2007-2008	Non-Market	Egypt	WTP for guided tour and guide book hire for an artificial snorkel trail to protect natural reefs from trampling	€13.42 per person per day for guided snorkel trip €14.38 per person per day for guide book hire fee	$17.24 per person per day for guided snorkel trip $18.56 per person day for guide book hire fee
Hicks et al. 2004	Oyster reef	Use-direct (Recreation/Tourism) Non-use		Market Non-market (TCM & CVM)	USA	Total WTP of recreational fishers for oyster reef restoration General public's WTP for oyster reef restoration Payment vehicle: Increase in annual income tax	$638,259 per year $86.68 per household per year	$1,005,391 per year $136.54 per household per year
Huth et al. (2015)	Shipwreck	Use-direct (Recreation/Tourism)	2013	Non-market (TCM & CBM[5])	USA	WTP of divers diving on all reef types and natural reefs with and without a new shipwreck	$6,531 /$6,163 per year on all reef types with/without new shipwreck $3,802/$3,685 per year on natural reefs	$7,198 /$6,793 per year on all reef types with/without new shipwreck $4,190/$4,062 per year on natural reefs

Study	AR[1] Type(s)	Value Type(s)	Data Collection Year	Valuation Method(s)	Country	Valuation Context/Description	WTP (study units)	WTP (2019 USD)
							with/without new shipwreck	with/without new shipwreck
Islam et al. (2014)	Various sunken objects (ships, tyres, concrete objects/structures, oil and gas platforms)	Use – Direct (Artisanal fishing)	2011	Market	Malaysia	Revenue associated with commercial fishing (small-scale/artisanal)	$164 per fisher per month	$185.34 per fisher per month
Johns et al. (2001)	Unspecified	Use – Direct (Recreation/Tourism)	2000	Market and Non-Market (CVM)	USA	WTP an extra amount in trip costs to maintain the AR in its existing condition WTP in annual boat registration/higher charter fees for an artificial reef program	$8.63 extra pp per day to maintain AR $75 pp per year for a program that maintains existing ARs $24 pp per year to create new ARs	$12.74 extra pp per day to maintain AR $110.12 pp per year for a program that maintains existing ARs $35.43 pp per year to create new ARs
Kasim et al. 2003	Concrete Structures	Use – Direct (Commercial fishing)	2007	Market	India	Net income from commercial fishing	INR1252 per unit operation per year for gillnet fisheries INR4650 per unit operation per year for hooks and line fisheries	$42.75 per unit operation per year for gillnet fisheries $158.77 per unit operation per year for hooks and line fisheries
Kirkbride-Smith et al. (2016)	Sunken Ships	Use – Direct (Recreation/Tourism)	2013	Non-Market (CVM)	Barbados	WTP an extra amount in trip costs for recreation in the Folkestone Marine Reserve	$17.58 extra pp per day	$19.18 extra pp per day
Leeworthy et al. 2006	Sunken Ships	Use – Direct (Recreation/Tourism)	1997	Market	USA	Revenue associated with recreational fishing and diving/snorkelling tourism	$2.6 million in total recreational expenditure	$4.12 million in total recreational expenditure
Milon (1988)	Sunken Ships	Use – Direct (Recreation/Tourism)	1985	Non-Market (TCM & NMNL)	USA	Benefits of a new centrally-located artificial reef site for private boat sport anglers	$1.80 pp per year	$4.28 pp per year

Study	AR[1] Type(s)	Value Type(s)	Data Collection Year	Valuation Method(s)	Country	Valuation Context/Description	WTP (study units)	WTP (2019 USD)
Morgan et al. (2009)	Sunken Ships	Use – Direct (Recreation/Tourism)	2006	Non-Market (TCM & CVM)	USA	Travel costs for divers to visit the USS Oriskany Divers' WTP for an additional sunken ship	$480-$750 pp per trip to the Oriskany $220-$1160 pp per year for an additional ship	$605.24-$945.69 pp per trip to the Oriskany $277.40-1462.67 pp per year for an additional ship
Morgan et al. (2018)	Sunken Ships	Use – Direct (Recreation/Tourism)	2014	Non-Market (CVM)	USA	WTP an increased saltwater fishing license fee	$32.71 pp per year in additional license fee	$35.12 pp per year in additional license fee
Oh et al. (2008)	Unspecified	Use – Direct (Recreation/Tourism)	1997	Non-Market (CVM)	USA	WTP additional diving trip costs	$101 extra pp per year	$159.97 extra pp per year
Pendleton (2005)	Sunken Ships	Use – Direct (Recreation/Tourism)	2002	Market and Non-Market (TCM)	USA	Revenue associated with dive tourism Travel costs for divers to dive the Yukon artificial reef	$4.5 million in market contribution $1..2 million in non-market contribution ($110 pp per day)	$6.36 million in market contribution $1.70 million in non-market contribution ($156.62 pp per day)
Polak and Shashar (2013)	Concrete Structures	Use – Direct (Recreation/Tourism)	2010	Non-Market (CVM)	Israel	WTP to restore ARs (biological attributes coral size, coral diversity, fish abundance, coral abundance, a combination of numbers of fish and corals, and fish and coral biodiversity) using varying degrees of effort	NIS10-35 pp per year (low effort) NIS15-50 pp per year (medium effort) NIS25-70 pp per year (high effort)	$3.05-$10.67 pp per year (low effort) $4.57-$15.24 pp per year (medium effort) $7.62-$21.34 pp per year (high effort)
Ramos et al. (2006)	Concrete Structures	Use – Direct (Commercial fishing)	2002	Market	Portugal	Net income associated with commercial fishing	€7858-€18896 per fisherman per year, depending on boat type	€11652.94-€28021.64 per fisherman per year, depending on boat type
Vivekanandan et al. (2009)	Various sunken objects (concrete, and high-density polyethylene objects)	Use – Direct (Artisanal fishing))	2003	Market	India	Income associated with artisanal fishing	RS71.3 per hour of operation	$2.93 per hour of operation
Westerberg et al. (2013)	Wind Turbines	Use – Direct	2010	Non-Market (DCE)	France	Additional cost of accommodation to have access to reef and wind farm associated recreational activities	€39.60 pp per week (no wind farm)	$50.04 pp per week (no wind farm)

Study	AR[1] Type(s)	Value Type(s)	Data Collection Year	Valuation Method(s)	Country	Valuation Context/Description	WTP (study units)	WTP (2019 USD)
		(Recreation/Tourism Visual Amenity)				Attribute levels: no wind farm, wind farm 5km offshore, wind farm 8km offshore, wind farm 12km offshore Payment vehicle: change in weekly accommodation price	-€76.1 pp per week (5km offshore) €13.3 pp per week (8km offshore) €43.9 pp per week (12km offshore)	-$96.17 pp per week (5km offshore) $16.80 pp per week (8km offshore) $55.48 pp per week (12km offshore)
Whitmarsh et al. (2008)	Concrete Structures	Use – Direct (Artisanal fishing)	1990-2005	Market	Portugal	Value per unit effort associated with artisanal fishing	€13 extra per unit effort on AR sites compared to (non-reef?) control sites €0.18 increase per unit effort per month	$18.47 extra per unit effort on AR sites compared to non-reef control sites $0.26 increase per unit effort per month
Wilhelmsson et al. (1998)	Various Sunken Objects (ships, dead coral heads)	Use – Direct (Recreation/Tourism)	1996	Market	Israel	Revenue associated with dive tourism excluding course dives and non-guided tours	$23 pp per dive $368,000 per year	$37.26 pp per dive $596,216.29 per year

[1] AR= Artificial reef; [2]DCE=Discrete Choice Experiment; [3]TCM=Travel Cost Method; [4]CVM=Contingent Valuation Method; CBM = Contingent Behaviour Method

Pipelines

Direct-use values

There are two studies that have estimated the in-situ value of fish stocks that are associated with pipelines. An additional nine studies have mentioned economic values of pipelines. The findings of these articles are briefly discussed below and shown in Table 10.

Bond et al 2018a found that the Echo Yodel pipeline on the Northwest shelf of Western Australia was characterised by large, commercially important species such as snappers (Lutjanidae) and grouper (Epinephelidae). They estimated that the biomass of commercial fish was approximately 7.5 times higher than in adjacent natural habitats. General species richness on the pipeline was about 25% greater than off the pipeline and relative abundance of fish was nearly double on the pipeline than in adjacent natural habitats. The association of commercially important species on the pipeline could be explained by their association with complex epibenthic habitat which was observed on the pipeline. As this habitat was previously degraded by trawling (Bond et al 2018c), the pipeline might provide important habitat and refuge for these commercial species. Consequently, the in-situ value of commercially important fish stocks on the pipelines (AUD 65.11 ± AUD 11.14 SE) was about 8.6 times higher than on natural sites (AUD 7.57 ± $2.41 SE).

Another pipeline (Griffin) on the Northwest shelf of Western Australia was also characterized by higher biomass and abundances of commercially important species such as goldband snapper (*Pristipomoides multidens*), saddletail snapper (*Lutjanus malabaricus*) and Moses' snapper (*Lutjanus russellii*) among others. Therefore, the pipeline possessed an in-situ value two to three times higher (AUD 32.87 ± AUD 8.21 SE) than off-pipeline (AUD 15.62 ± AUD 2.97) (Bond et al 2018b).

A number of other studies have also found higher abundance of commercial fish species around three obsolete wellheads (Wanea, Goodwyn and Echo) on the Northwest shelf of Western Australia (Pradella et al 2014) as well as along pipelines off Santa Barbara in the USA (Love and York 2005).

Due to the lack of valuation studies it remains unclear whether or to what extent a higher in-situ value of fish stocks along the pipelines translates into direct extractive use values for fishers. However, commercial and recreational fishers that operate on the Northwest shelf in Western Australia have anecdotally reported that their catch is higher along pipelines (McLean et al 2017).

Rouse et al 2018a found further evidence that fishers aggregate around pipelines in the UK. They estimated that over a five year period about a third (36.1%) of fishing trips happened within 200 m of pipelines. Also, the actual percentage of fishing effort was higher close to pipelines (2.52%) than on the same substrate off-pipelines (1.33%). They conclude that pipeline decommissioning can have negative impacts on fisheries through displacement of aggregated fishing effort. However, they also identify positive effects that pipeline decommissioning can have on fisheries through decreased interaction between fishing gear and pipelines. The possible threats from pipelines to fishers include the loss of access to fishing sites where pipelines are left on the seafloor as well as snagging hazards from pipelines (including loss or damage of gear, lost fishing time and risk of injuries to crew members). These risks can increase with time because more interactions between fishing gear and either the pipeline or its protective material can modify their structure (Rouse et al. 2018a). However, as noted before, the associated economic costs and benefits have not been evaluated. We also have found no studies that have measured the non-extractive direct use-value or indirect use-values associated with pipelines.

Non-use values

To the best of our knowledge, there is no valuation study that has investigated non-use values of pipelines. However, Rouse et al (2019) identified established epibenthic species on a pipeline in the UK, some of which have conservation value. Therefore, it could be inferred that there are non-use-values related to these species.

Echo Yodel

The Echo Yodel pipeline is located in approximately 140m water depth in the Dampier Sub Basin in Commonwealth waters. The production of two wells (Yodel 3 and 4) together with the pipeline was ceased in 2012. Therefore, the removal of these structures is currently being discussed. Below, we discuss what economic impact the removal of the Echo Yodel pipeline could have on relevant stakeholder groups.

Direct use values

The Northwest shelf maintains four fisheries (Open West Coast Fishery, the Pilbara Trawl Fishery, the Pilbara Trap Fishery and the North Coast Shark Fishery). However, only the trawl fishery has any noteworthy catch in water deeper than 50 m. The Yodel wells and pipeline lie in Zone 1 of Pilbara Trap Managed Fishery and adjacent to the Pilbara Trawl Fishery (Zone 2). As noted above, the Echo Yodel pipeline is characterised by large, commercially important species and it was estimated that their biomass is 7.5 times higher than in adjacent off-pipeline areas. Also, species diversity and relative fish abundance was higher on the pipeline than in close by natural habitats. Moreover, there is anecdotal evidence that commercial fishers target the pipeline because they are aware of higher catch rates on it. Therefore, the removal of the pipeline would most likely result in some loss in profit for these commercial fishers. On the other hand, there might be a potential increase in profit for trawl fisheries as the removal of the pipeline makes this area available to them.

Most recreational activities such as recreational fishing and diving are located within inshore waters. Therefore, economic values from recreational activities are not relevant to the removal of the pipeline.

Indirect use-values

We could not identify any indirect use values associated with the removal of the pipeline.

Non-use values

It is sensible to expect that residents of Western Australia would have some positive willingness to pay to maintain the higher fish biomass, abundance and biodiversity on the Northwest shelf. Therefore, these non-use values might be reduced or lost if the pipeline was removed. Conversely, it is possible that other members of the general public value habitats that are undisturbed from human intervention. In that case, the removal of the Echo Yodel pipeline would increase the value this area provides for them.

Table 10: Studies on the economic value of pipelines.

Reference	Study site	Value type	Valuation Context	WTP/Value	Unit	Data	Quote
Quantitative studies							
Bond et al 2018a	Echo Yodel, WA, Australia	In-situ value of commercial fish species	In-situ value of potential catch on and off pipeline as well as along a depth gradient	On pipeline: 65.11 ± 11.14, off pipeline: 7.57 ± 2.41	AUD/ deployment ± SE	2017	
Bond et al 2018b	Griffin, WA, Australia	In-situ value of commercial fish species	In-situ value of potential catch on and off pipeline as well as along a depth gradient	On pipeline: 32.87 ± 8.21, off pipeline: 15.62 ± 2.97	AUD/deploy ment ± SE	2017	
Qualitative studies							
Bond et al 2018c	Echo Yodel, WA, Australia	In-situ value of commercial fish species	N/A	N/A	N/A	2013	"The pipeline was characterised by a high abundance of commercially important snapper (Lutjanidae) and grouper (Epinephelidae) species. (…) Structurally complex mesophotic epibenthic habitat forming invertebrates were observed on the pipeline (…) These complex epibenthic habitats were considered to be important to commercial target species and the modification or loss of these habitats is thought to have negatively impacted the valuable commercial fisheries in the region. This study suggests pipelines can offer a significant epibenthic habitat and refuge for fish, potentially comparable to the historical habitats lost to trawling."
Love and York 2005	Santa Barbara, CA, USA	Not specified	N/A	N/A	N/A	2001 and 2002	"Compared to the seafloor habitats, overall fish numbers and densities were highest at the two pipeline habitats. Fish densities along the shallow portion of the pipeline were about seven times higher than on the adjacent seafloor and densities along the deep pipeline portion were nearly six times that of the deeper seafloor. (...) Similarly, species richness (defined as the number of species/ area surveyed) was greater in the pipeline habitat (W = 13, n = 23, P = 0.001) than on the seafloor."
McLean et al 2017	Echo Yodel and 2TL, WA, Australia	Direct-use (extractive)	N/A	N/A	N/A	2007, 2008, 2013 and 2014	"Both pipelines were characterised by a high abundance of commercially important fishes including: snappers (Lutjanidae) and groupers (Epinephelidae). The presence of thousands of unidentifiable larval fish, in addition to juveniles, sub-adults and adults suggests that the pipelines may be enhancing, rather than simply attracting, fish stocks." "Anecdotally, however, local commercial and recreational fishers report increased fish-take close to pipelines (D. Gibson pers. com.)." "Commercially important fish species were ubiquitous and abundant on both the EY and 2TL pipelines. The surveyed section of the EY pipeline is within the boundaries of the Pilbara Trap Managed Fishery and the Pilbara Line Fishery (…) However, fish species comprising the majority of commercial catches in the Pilbara differed from the most abundant and ubiquitous target species observed on the pipelines."

Reference	Study site	Value type	Valuation Context	WTP/Value	Unit	Data	Quote
Pioch et al. 2011	Mayotte Island, France	Not specified	Fish abundance on new pipeline with "eco-weights" compared to old pipeline without	N/A	N/A		"Fish abundance on the old pipeline, still in use and located 5 m away from the new construction, was insignificant. In contrast, schools of >15 fishes from 3 to 5 different families were seen on the new pipeline (L. Bigot, personal communication). Monitoring of the biota on the new construction will continue for 3 years. The first video was shown to the stakeholders (artisanal fishermen, scuba divers) and policy makers. They were pleased to see that the project did return technical and ecological services with socio-economic benefits."
Pradella et al 2014	WA, Australia	Direct-use (extractive)	N/A	N/A	N/A		"Fishes from 14 families and 31 species were observed associating with the structures. (...) Ten of the species observed are commercially fished in the region, although only three (…) are major target species.
Rouse et al. 2017	UK, North Sea	Direct-use (extractive)	Decommissioning effects on commercial fisheries				"The societal impacts that must be considered in the comparative assessment include the consequences of decommissioning to commercial fishers. These include potential snagging hazards from in situ decommissioned pipelines, and loss of access either during the decommissioning process and/or as a result of disused pipelines left on the seabed (de Groot, 1982; Jiexin et al., 2013). Snagging can potentially result in damage to gear, loss of fishing time and/or risk of injuries to crew. Additionally, physical contact between fishing gear and decommissioned pipelines can be a risk to pipeline integrity and, over time, increase the snagging hazard posed by the pipeline (Ellinas et al., 1995; Det Norske Veritas (DNV), 2006). Repeated trawling activity may also disturb any protective material (such as rock placement) which has been added to in situ decommissioned pipelines to mitigate snagging risks."
Rouse 2018	UK, North Sea	Direct-use (extractive)	Comparison of effects from decommissioning options on seabed recovery and interactions with commercial fisheries	N/A	N/A		"Decommissioning all pipelines in situ had the smallest spatial foot print of the in situ scenarios, but offers no mitigation for fisheries risks. Rock dumping pipelines occupies a smaller area of seabed than establishing fisheries exclusion zones around pipelines, but the effects of rock dump on the ecosystem are unknown and may constitute a significant change to the seabed (Lindeboom et al., 2011). These changes will include loss of underlying soft-sediment habitats and an increase in the surface area available for colonisation by epibenthic organisms, with the potential for delivery of ecosystem services associated with natural hard substrates (Miller et al., 2013)."
Rouse 2018	UK, North Sea	Direct-use (extractive)	Decommissioning effects on commercial fisheries	N/A	N/A	2009-2013	"Approximately one-third (36.1%) of trips fished within 200 m of a pipeline over a 5-year period, suggesting that pipelines are subjected to regular interaction with fishing gear. The fishing effort (in hours) associated with pipelines was 2.52% of the total effort, compared to 1.33% in an equivalent area of seabed 1 km away, implying modest aggregation of fishing around pipelines. Only a small percentage (0.93%) of fishing trips actively targeted pipelines as fishing grounds. (...) The results suggest that pipeline decommissioning may have both negative (displacement of aggregated effort) and positive (reduced snagging potential) outcomes for commercial fisheries."

Reference	Study site	Value type	Valuation Context	WTP/Value	Unit	Data	Quote
Rouse 2019	UK, North Sea	"Conservation value"	Decommissioning effects on associated species	N/A	N/A	2013-2016	“Pipelines have traditionally been excluded from North Sea connectivity/larval dispersal models (Hyder et al., 2017), but our results, documenting the presence of marine fauna on pipelines, suggest that pipelines will, to some extent, contribute to the connected network of some taxa. The extended linear presence of pipelines over the seabed, connecting larger areas of artificial hard substrate (i.e., platforms), could mean that pipelines facilitate dispersal of epifauna.(…) The results suggest that removal of pipelines will remove established colonies of epibenthic species, some of which have conservation value."

Oil and gas platforms

Direct-use values

Oil and gas platforms have been found to generate direct use values in terms of business revenues from both extractive uses (such as commercial fishing, recreational fishing) and non-extractive uses (such as scuba diving).

Hiett and Milon (2002) found that recreational fishing and diving associated with oil and gas 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 oil and gas structures to be very important to their businesses. In Texas, USA, the annual business revenues associated with diving on a variety of artificial reefs - including decommissioned oil and gas platforms – were estimated as USD 261,439 to USD 784,106 (Ditton et al. 2001). However, results are not divided by artificial structure types, and so the fraction that can be attributed to oil and gas structures is unknown.

Oil and gas structures have been also found to increase the satisfaction of recreational fishers through the increase the catchability and/or the catch rate during their fishing trips. McGurrin and Fedler (1989) used the contingent valuation method to compare the perception of fishers that fish on and off an oil and gas platform and found that platform users felt that both the size and types of fish that could be caught were better than off the structure. Consequently, fishers that fished on oil and gas platforms were willing to pay more (USD 19.38) for another artificial reef site than non-platform fishers (USD 10.00).

Roberts et al 1985 used a contingent valuation method to estimate the economic value that oil and gas structures provide for recreational divers in Louisiana, USA. Their results show that the average diver derived a consumer surplus of $163 annually from this activity.

Three studies have looked at the economic benefits that oil and gas platforms can generate for commercial fisheries. One example are the oil and gas platforms in the Gulf of Mexico which provide habitat for snapper populations. As a result, a significant part of the commercial harvest of snappers originates from petroleum platforms (Bull and Love, 2019). However, Islam et al. 2004 found that benefits from artificial reefs –including oil and gas 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.

Another potential source of economic value from offshore oil and gas structures is the harvest of ornamental fish. 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 platform per year. Moreover, they point out that there is an unknown value in novel pharmaceutical and/or nutritional products that could be sourced from marine invertebrates that grow on oil and gas platforms.

Non-use values

Non-use values result from peoples' satisfaction with natural resources that are not traded in a market. To our knowledge, there is no literature on the non-use values that oil and gas platforms provide.

All economic valuation studies on oil and gas platforms are shown in Table 11.

Thevenard

As outlined above, literature has shown that oil and gas platforms can create substantial economic values for various user groups. In Thevenard, production from the offshore fields ceased in January 2014 and therefore a decision has to be made about the decommissioning of the oil and gas structures. These structures are in particular three platforms, six monopods and one pipeline. As different decommissioning options would create different values, this section provides an indication of the values that may be lost or generated if the existing Thevenard oil and gas infrastructure were to be either completely removed (Figure 12, option a) or used to generate artificial reefs through partial removal (option b) or toppling (option c). The exact form and location of a potential artificial reef is yet to be decided. As the latter two options would have a similar effect on economic values, we are treating them as one scenario.

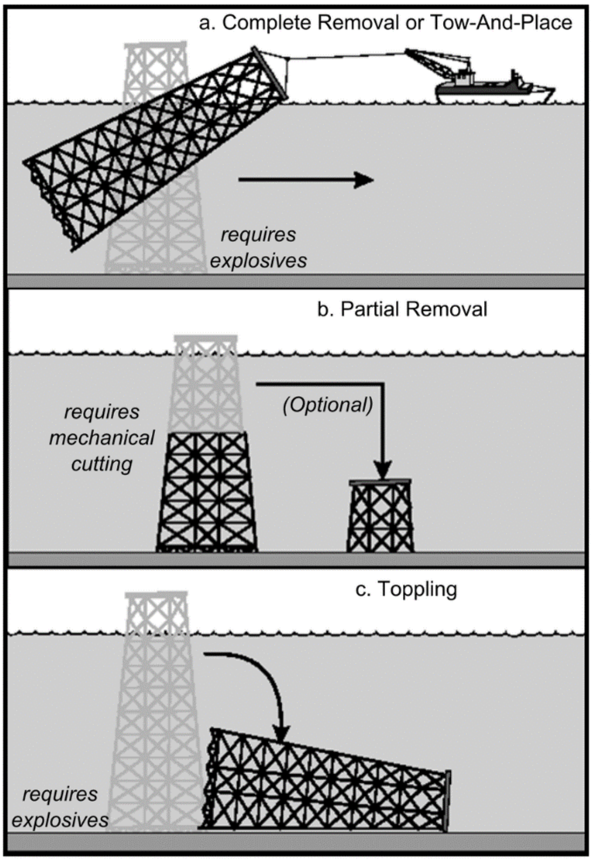

Figure 12: Decommissioning options for oil and gas platforms (adapted from Bull and Love 2019).

Complete removal

To this very moment, there is a 500 m exclusion zone around the platforms and monopods in the Thevenard Island region. However, there are indications that de facto these structures are being used from recreational fishers and divers. Therefore, the direct use-values (both extractive and non-extractive) associated with the recreational use of the structures would be lost if they were completely removed. There is no information about the use of the pipeline in the area, but if there are any values associated with it, those would be lost by the removal.

Under the status quo, indirect use values might be present for recreational fishers, divers and commercial fishers through spill-over effects. Therefore, the complete removal of the oil and gas structures would also remove these values.

Moreover, the full removal scenario would permanently remove all sessile marine life that is currently living on the structures. It is not clear to what extent this scenario would impact the marine fauna that is able to relocate itself but depends on the structure for feeding, protection from predation and/or reproduction. This impact is most likely different for each species (and/or life stage of each species). In any case, the existence values that people hold for the marine life associated with these structures would be largely reduced or even lost with the full removal. Conversely, existence values for natural marine habitats without marine man-made structures would be gained under the full removal scenario.

Partial removal and toppling

Under a scenario where the oil and gas structures are partially removed or toppled to create one or various new artificial reefs, the economic values that would arise will depend, from both an ecological and economic perspective, on the objectives, characteristics and locations chosen for new artificial reef(s). It is worth noting, that the manipulation of the structures to create artificial reefs involves the use of explosives or mechanical cutting and can partially or completely remove the marine life currently living on it. Depending on the new application of these structures, this is likely a temporary removal as life might either return to the structures or new life would settle on it again. In theory, all of the economic value types that are discussed in sections 3.1 and 3.2 could potentially be influenced:

- Direct use values
    - Extractive use values through commercial and recreational fishing activities
    - Non-extractive use values through scuba diving, snorkelling, surfing or other recreational activities
- Indirect use values
    - Coastal protection
    - Spill-over effects
- Non-use values
    - Existence values for species associated with artificial reefs
    - Loss of existence values for habitats without man-made structures

Table 11: Economic valuation studies on oil and gas platforms.

Study	AR Type(s)	Value Type(s)	Data Collection Year	Valuation Method(s)	Country	Valuation Context/Description	WTP (study units)	WTP (2019 USD)
Ditton et al. (2001)	Various sunken objects (man-made materials, shipwrecks, oil and gas platforms)	Use – Direct (Recreation/Tourism)	1997	Market	USA	Revenue associated with commercial dive tourism	$162 pp per diving trip day for Texas residents $170 pp per diving trip day for Texas non-residents	$256.58 pp per diving trip day for Texas residents $270.67 pp per diving trip day for Texas residents
Hiett and Milon (2002)	Oil and gas platforms	Use – Direct (Recreation/Tourism)	1999	Market	USA	Revenue associated with commercial dive tourism and recreational fishing	$4691 per angler per year ($13 per angler per day)	$7157.63 per angler per year ($20 per angler per day)
Islam et al. (2014)	Various sunken objects (ships, tyres, concrete objects/structures, oil and gas platforms)	Use – Direct (Artisanal fishing)	2011	Market	Malaysia	Revenue associated with commercial fishing (small-scale/artisanal)	$164 per fisher per month	$185.34 per fisher per month
Kolian et al. (2018)	Oil and gas platforms	Use- Direct (Pharmaceutical products)	N/A	Market	USA	Potential harvest: Market price of $20/invertebrate and $10/fish and a sustainable yield of 10% of the population (50000 invertebrates and 4000 fish/year) per platform	$14 million per platform per year	14.3 million per platform per year
McGurrin and Fedler (1989)	Oil and gas platforms	Use – Direct (Recreation/Tourism)	1989	Non-Market (CVM)	USA	Willingness to pay for an additional AR	$14.36 pp one-off payment	$29.44 pp one-off payment
Roberts et al. (1985)	Oil and gas platforms	Use - Direct (Recreation/Tourism)	1982	Non-Market (CVM)	USA	Willingness to pay for annual pass to dive under offshore oil and gas rigs	$163 pp per year	$429.38 pp per year

[1]DCE=Discrete Choice Experiments; [2]TCM=Travel Cost Method; [3]CVM=Contingent Valuation Method

Piers and jetties

To our knowledge, there are no economic valuation studies on piers and jetties. However, the Australian Department of Planning, Transport and Infrastructure has recognised the importance of piers and jetties for residents and is conducting research on the usage and the economic benefits of jetties in South Australia (https://yoursay.sa.gov.au/decisions/yoursay-engagements-sa-jetties-strategic-plan/about).

Exmouth Navy Pier

The Point Murat Navy Pier (from here on only Navy Pier) is located at the mouth of Exmouth Gulf and is adjacent to Bundegi Reef in the Ningaloo Marine Park. It was constructed in 1964 to service the US Naval Communication Station and is nowadays mainly used to supply the base with fuel. The general public has no access to the base. The waters 400 m around the Navy Pier structure is protected under Commonwealth Defence since 1964. In 2005 an additional area was included in the Ningaloo Marine Park as the Point Murat Sanctuary Zone. Therefore, the Navy Pier offers no extractive direct use-values. However, one local dive company has the permission to conduct scuba diving tours underneath the pier which generates non-extractive direct-use values through dive tourist expenditures, multiplier effects and the consumer surplus from dive tourists.

Ecological surveys on the Navy Pier have confirmed a high biodiversity, including over 160 species of finfish from 50 families (Whisson & Hoschke 2013). Given the long history of protection at this site, it is likely that some fish spill over into surrounding areas. Therefore, it is likely that the Navy Pier generates indirect use-values in form of improved fishing experience for recreational fishers in the region.

Moreover, the Navy Pier was identified as an aggregation site for the grey nurse shark (*Carcharias taurus*) which is completely protected within Australian waters since 1997 (Hoschke & Whisson 2016). Therefore, it is very likely that the general public holds existence values for the biodiversity including protected species that are associated with the Navy Pier.

Attraction vs. production

It becomes evident from the literature that the economic values associated with MMI largely depend on their capacity to enhance the marine environment. While it is widely acknowledged that the presence of artificial structures have increased fish populations around them, there is a continuing discussion about whether these structures merely attract and aggregate fish or also increase the production of existing fish stocks (Bull & Love, 2019). Researchers that found an aggregation effect on artificial reefs are concerned that artificial reefs increase the vulnerability of fish populations to fishing and therefore contribute to overfishing (Pickering & Whitmarsh 1997). However, some researchers have found that various species use artificial structures as nursery grounds and therefore increase the production of these species (Claisse et al., 2014). While the degree of attraction and production effects in each artificial reef varies, this most likely has effects on the behaviour of reef users and consequently the economic benefits that these structures provide.

It is worth noting that the impacts of aggregation versus production are likely to have different impacts on the different values, and that aggregation, although not causing an increment in the underlying ecology, and hence have no impact on non-use values, may still create benefits for use values, if it reduces costs. Fisheries management such as harvest restrictions, temporal closures or the designation of some AR as no-take areas could ensure that artificial reefs meet their targets and maintain ecologically and economically sustainable fisheries.

Discussion

An overall summary of the social and economic literature identified in the review process with reference to the study sites which represent the focus of primary data collection in this research is summarised in Table 12. These are categorised into instances of either hard evidence which relates directly to a study site, or inferred evidence which identifies cases where data can be extrapolated from another location and applied to one of the case study sites. Cases where there is no hard or inferred evidence are left blank. This may be due to the fact that a stakeholder group has no relationship with a specific structure – e.g. fishing is not permitted around the Navy Pier, hence the cells are blank – or that there exists no data which can be inferred for the relationship between a stakeholder group and a particular type of MMI structure.

The first point to note from Table 12 is that there is only one instance where hard evidence relating to social or economic values and perceptions can be utilised. This relates to the evaluation of direct use benefits to commercial fishers arising from fish biomass around Echo Yodel conducted by Bond et al (2018). The second point to note is that the literature enables most inferences to be drawn in relation to artificial reefs, as these are consistently the most 'popular' form of MMI in the literature. Similarly, recreational divers and (to a slightly lesser extent) non-governmental organisations are the stakeholder groups for whom economic and social evidence can be inferred most frequently. This does come with a distinct caveat, however, as there is only one publication which discussed the social values of recreational fishers associated with an artificial reef and dates from 1994. Consequently, the ability to 'infer' data in relation to the case study sites for the current research must be understood in relation to the quantity and range of evidence in the literature.

There are several broader issues arising from the literature review which merit comment. The first of these is that no publications either in the academic or professional literature attempt to consider both social and economic values and perceptions of stakeholder groups with reference to MMI. This is of significance as the theoretical literature consistently points to inter-dependencies between social and economic values and perceptions, with one being informed or influenced by the other. Secondly, the literature does not reflect or recognise the heterogeneity within stakeholder groups, which clearly does not reflect the reality of diverse characteristics of individuals within stakeholder groups and their divergent values and perceptions of both social and economic benefits of MMI. Finally, the literature considers examples of values and perceptions of MMI on an individual basis, with no consideration of inherent systemicity whereby individual or collective values and perceptions will be coloured by the degree of knowledge or experience of other MMI sites.

These broader issues, together with the gaps in knowledge identified in Table 12, will be addressed in the next stages of this research through a combination of online surveys and workshops. The outcomes of these will be discussed at the appropriate time with the Steering Committee and will be reported in detail in the next Report.

Table 12: Available evidence and data as identified through the literature review for the case study locations. S = Social; E = Economic

	Exmouth Artificial Reef	**Navy Pier**	**Thevenard Island**	**Echo Yodel Pipeline**	**Busselton Jetty**
Commercial Fishers	S: Inferred		S: Inferred		
			E: Inferred	Economic: **Hard Evidence**	
Recreational Fishers	S: Inferred		S: Inferred		
	E: Inferred		E: Inferred		E: Inferred
Recreational Divers	S: Inferred	S: inferred	S: Inferred		
	E: Inferred	E: Inferred	E: Inferred		E: Inferred
Non-Government Organisations	S: Inferred				
	E: Inferred	E: Inferred	E: Inferred	E: Inferred	E: Inferred
Government (Local and State)	S: Inferred				
	E: Inferred	E: inferred	E: inferred	E: inferred	E: Inferred

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Appendices

Appendix 1: Social Values Literature Review Criteria

Table 13: Search terms applied in academic literature review

	Level 1: Structures AND	Level 2: Values AND	Level 3 Uses OR	Level 4 Objectives
Synonyms	Artificial reef	Well*being	Recreational fishing	Marine restoration
	Oil pipeline	Social value	Commercial fishing	Decommissioning
	Gas pipeline	Perception	Fishing	
	Pier	Value*	Ecotourism	
	Jetty	socioeconomic	Touris*	
	Oil platform	Soci* ecological	Recreational diving	
	Gas platform		Diving	
	Oil and gas platform			
	Offshore structures			
	Aquatic infrastructure			

Table 14: Inclusion and exclusion criteria applied in academic literature review

Inclusion	**Exclusion**
Initial	
Written in English	Written in other languages
1989 - 2019	Pre 1989
Peer-reviewed journal article or review	Book chapters, non peer-reviewed, conference proceedings
All hits using Web of Science & Scopus	
First 100 hits using Google Scholar	Hits greater than 100
Secondary	
Explicit focus on the social value of man-made marine structures	Social values incidental to focus
Full text available through university access rights	Full text unavailable through university access rights
Type of study (empirical data, review, theory) ~ all types.	

Table 15: Professional literature search terms

Structures	Environment	Values	Users	Objectives
• Man-made structures • Marine Infrastructure • Subsea pipelines • Offshore installations • Oil and gas pipelines • Artificial structures • Offshore windfarm • Offshore oil and gas • Artificial reef	• Marine Environment • Ecosystem	• Social value • Human well-being • Perceptions	• Fisheries • Stakeholders • Community • Public	• Marine date acquisition • Decommissioning • Marine Management • Consultation • Maximising socio-economic benefits • Policy change

Table 16: Professional literature organisations

Organisation Name
AUSTRALIA
WAFIC
Department of Biodiversity, Conservation and Attractions
Department of Primary Industries and Regional Development -> fisheries
Chevron
National Energy Resources Australia
Recfish West
National Offshore Petroleum Safety and Environmental Management Authority
APPEA
Department of industry, innovation and science
Subcon
NOGA
Shell Australia
ARPANSA
BHP
ConocoPhillips
Woodside
UNITED KINGDOM
INfluence of man-made Structures In The Ecosystem (INSITE)
Department for Environment Food & Rural Affairs (UK Gov)
Marine Management Organisation (UK Gov)
Department for Business, Energy & Industrial Strategy (UK Gov)
Centre for Environment Fisheries and Aquaculture Science (UK Gov)
Oil and Gas Authority (UK Gov)
The Oil and Pipelines Agency (UK Gov)
Marine & Fisheries (Scottish Gov)
Marine and fisheries (Welsh Gov)
Department of Agriculture, Food and Marine (Irish Gov)
Oil and Gas UK
UNITED STATES
Environmental Protection Authority
Florida Fish and Wildlife Conservation Commission

NOAA National Sea Grant Library
NOAA Fisheries
NOAA National Marine Sanctuaries, Florida Keys Socioeconomic Monitoring Program
National Ocean Economics Program

Appendix 2: Social Value Literature 2 or 3 Stars

Table 17: Academic literature review articles rated 2 or 3 stars

Rating*	Theme	Reference	ID
3	Social: Well-being	Barclay K., Voyer M., Mazur N., Payne A.M., Mauli S., Kinch J., Fabinyi M., Smith G. (2017) The importance of qualitative social research for effective fisheries management, Fisheries Research, 186: 426- 438	1
3	Use & Satisfaction	Belhassen, Y., Rousseau, M., Tynyakov, J., & Shashar, N (2017) Evaluating the attractiveness and effectiveness of artificial coral reefs as a recreational ecosystem service, Journal of Environmental Management, 203 (1): 448 - 456	2
3	Use & Satisfaction	Kirkbride-Smith A.E., Wheeler P.M., Johnson M.L. (2013) The Relationship between Diver Experience Levels and Perceptions of Attractiveness of Artificial Reefs - Examination of a Potential Management Tool, PLoS ONE, 8(7)	3
3	Perceptions: RA	Kruse S.A., Bernstein B., Scholz A.J. (2015) Considerations in evaluating potential socioeconomic impacts of offshore platform decommissioning in California, Integrated Environmental Assessment and Management, 11 (4): 572-583	4
3	Perceptions: G	Murray, J. D., & Betz, C. J. (1994) User views of artificial reef management in the southeastern US, Bulletin of Marine Science, 55: 970 - 981	5
3	Perceptions: G	Ramos, Jorge; Santos, Miguel N.; Whitmarsh, David; Monteiro, Carlos C. (2007) Stakeholder perceptions regarding the environmental and socio-economic impacts of the Algarve artificial reefs, Hydrobiologia, 580: 181 - 191	6
3	Social: Interests	Ramos, J., Santos, M., Whitmarsh, D., & Monteiro, C. (2011b) Stakeholder analysis in the Portuguese artificial reef context: winners and losers, Braz. J. Oceanogr, 59: 133-143	7
3	Perceptions: G	ten Brink T.S., Dalton T. (2018) Perceptions of commercial and recreational fishers on the potential ecological impacts of the Block Island Wind Farm (US), Frontiers in Marine Science, 5: 439	8
3	Social: Interests	Schroeder D.M., Love M.S. (2004) Ecological and political issues surrounding decommissioning of offshore oil facilities in the Southern California Bight, Ocean and Coastal Management, 47: 21-48	9
2	Perceptions: RA	Ammar, M. S. A. (2009) Coral Reef Restoration and Artificial Reef Management, Future and Economic, Open Environmental Engineering Journal, 2 (1): 37-49	10
2	Perceptions: G	Andriesse E. (2018) Persistent fishing amidst depletion, environmental and socio-economic vulnerability in Iloilo Province, the Philippines, Ocean and Coastal Management, 157: 130- 137	11
2	Perceptions: G & RA	Hooper T., Ashley M., Austen M. (2015) Perceptions of fishers and developers on the co-location of offshore wind farms and decapod fisheries in the UK, Marine Policy, 61: 16- 22	12
2	Perceptions: G	Hooper T., Hattam C., Austen M. (2017) Recreational use of offshore wind farms: Experiences and opinions of sea anglers in the UK, Marine Policy, 78: 55-60	13
2	Perceptions: G	Kienker, S. E., Coleman, R. A., Morris, R. L., Steinberg, P., Bollard, B., Jarvis, R., . . . Strain, E. M. A. (2018), Bringing harbours alive: Assessing the	14

		importance of eco-engineered coastal infrastructure for different stakeholders and cities, Marine Policy, 94: 238 - 246	
2	Perceptions: G	Lima J.S., Zappes C.A., Di Beneditto A.P.M., Zalmon I.R. (2018), Artisanal fisheries and artificial reefs on the southeast coast of Brazil: Contributions to research and management, Ocean and Coastal Management,163: 372-382	15
2	Social: Asset	Pike, K., Johnson, D., Fletcher, S., Wright, P., & Lee, B (2010), Social Value of Marine and Coastal Protected Areas in England and Wales, Coastal Management, 38(4): 412 - 432	16
2	Social: Well-being	Ramos, J; Santos, MN; Whitmarsh, D; Monteiro, CC (2006) The usefulness of the analytic hierarchy process for understanding reef diving choices: A case study, Tourism Geographies, 14(3): 361-382	17
2	Perceptions: G	Shani A., Polak O., Shashar N. (2012) Artificial Reefs and Mass Marine Ecotourism, Tourism Geographies, 14 (3): 361-382	18
2	Perceptions: RA	Sutton S.G., Bushnell S.L. (2007) Socio-economic aspects of artificial reefs: Considerations for the Great Barrier Reef Marine Park, Ocean and Coastal Management, 50(10): 829-846	19
2	Perceptions: G	Tessier A., Francour P., Charbonnel E., Dalias N., Bodilis P., Seaman W., Lenfant P. (2015), Assessment of French artificial reefs: due to limitations of research, trends may be misleading, Hydrobiologia, 753 (1)	20
2 SB	Social: Asset	A.J. Evans, B. Garrod, L.B. Firth, S.J. Hawkins, E.S. Morris-Webb, H. Goudge, P.J. Moore (2017) Stakeholder priorities for multi-functional coastal defence developments and steps to effective implementation, Mar. Pol. 75: 143–155.	21
2 SB	Perceptions: G	Ditton, R.B., Osburn, H.R., Baker, T.L. and Thailing, C.E. (2002) Demographics, attitudes, and reef management practices of sport divers in offshore Texas waters. ICES Journal of Marine Science 59, 186–191.	22
2 SB	Social: Well-being	R.L. Morris, G. Deavin, S.H. Donald, R.A. Coleman (2016) Eco-engineering in urbanised coastal systems: consideration of social values, Ecol. Manag. Restor. 17 (1) (2016) 33–39.	23
2	Social: Well-being	Voyer, M., Barclay, K., McIlgorm, A., & Mazur, N. (2017) Connections or conflict? A social and economic analysis of the interconnections between the professional fishing industry, recreational fishing and marine tourism in coastal communities in NSW, Australia. Marine Policy, 76, 114-121	24
2	Use & Satisfaction	Stolk P., Markwell K., Jenkins J.M. (2007) Artificial reefs as recreational scuba diving resources: A critical review of research, Journal of Sustainable Tourism, 15(4): 331- 350	25
2	Perceptions:TI	Cripps SJ and Aable JP (2002), Environmental and socio-economic impact assessment of Ekoreef, a multiple platform rigs-to-reef development, Journal of Marine Science, 59: 300-308.	26

*(SB) indicates a paper identified through snowballing.

Table 18: Professional literature review documents rated 2 or 3 stars

Rating*	Theme	Reference	ID
3	Perceptions: RA & TI	Shaw J.L., Seares P., Newman S.J. (2018) Decommissioning offshore infrastructure: a review of stakeholder views and science priorities, Available online from: http://www.marinescienceblueprint.org.au/	P1
2	Perceptions: RA & TI	WAFIC (2017) Thevenard Offshore Platform Retirement Commercial Fishing Sector Stakeholder Consultation – WAFIC Report. Available from: https://www.wafic.org.au/offshore-stakeholder-consultation-environment-plans-nopsema-update-commercial-fishers/	P2
2	Perceptions: G	CRC Research Centre (1999) Understanding public perceptions of the Great Barrier Reef and its management, Available online from: http://rrrc.org.au/wp-content/uploads/2014/03/Technical-Report-29.pdf	P3

2	Use & Satisfaction	CRC Reef Research Centre (1998), Visitor experiences and perceived conditions on day trips to the Great Barrier Reef, Available from: http://rrrc.org.au/wp-content/uploads/2014/03/Technical-Report-21.pdf	P4
2	Perceptions: G & TI	Leeworthy, Wiley and Hospital (2004) Importance-Satisfaction Ratings Five-year Comparison, SPA & ER Use, and Socioeconomic and Ecological Monitoring Comparison of Results 1995-96 to 2000-01, Available online from: https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/archive/science/socioeconomic/floridakeys/pdfs/impsat.pdf	P11
2	Use & Satisfaction	Montes, N., Sidman, C., Lorenzen, K., Tamura, M. and Ishida, M., (2019) Influence of fish aggregating devices on the livelihood assets of artisanal fishers in the Caribbean, Ocean & Coastal Management, 179: 104823.	P12
3	Social: Interests & Perceptions: G	Bates (2016) Key Challenges Of Offshore Wind Power: Three Essays Addressing Public Acceptance, Stakeholder Conflict, And Wildlife Impacts, PhD Thesis, Available online from: http://udspace.udel.edu/handle/19716/19780	P13

Appendix 3: Social Value Review Templates

Social Value Academic Literature Review

	Al-Horani and Khalaf 2013
Document type	Research based peer reviewed article
Title	Developing artificial reefs for the mitigation of man-made coral reef damages in the Gulf of Aqaba, Red Sea: coral recruitment after 3.5 years of deployment
Summary	Article examines rates of coal colonisation on a deployed artificial reef 3.5 yrs after deployment to test their conservation outcomes
Geographic region	Gulf of Aqaba, Red Sea
Structure Type	Artificial reef with high structural complexity
Stakeholders / sectors	None
Social values explored	None
Methods:	What approach was adopted to engage stakeholders
	NA – no stakeholders engaged
	What approach was adopted to identify and evaluate social values
	NA – no social values evaluated
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	NA
Other findings	Issues
	Structures: Special concern should be given to the structural design of the AR and the materials used for its construction. Those two factors are of prime importance for the success of the AR in achieving its set goals, especially if habitat restoration is required.
Other findings	Opportunities
	The AR offers additional ecological benefits through its ability to trap sediments and seawater filtration through its filter feeders. Therefore, it is recommended to use ARs for restoration purposes in areas that have denuded reefs. They may represent attractive recreational diving sites in areas of intensive dive use, and therefore have the potential to protect the natural reefs (p. 756).
Thoughts/reflections	1: No focus on social values, the last sentence of the paper makes minor reference to the potential for ARs to be dive sites.

Ref ID# 10	Ammar et al 2009
Document type	Review, peer reviewed article
Title	Coral Reef Restoration and Artificial Reef Management, Future and Economic
Summary	This paper reviews conditions driving the need for restoration, and the questions that must be considered to identify the type of restoration necessary or possible. Artificial reefs around the world, their uses, social and economic impacts, liability, the use of novel technology approaches in artificial reefs and future applications were also reviewed
Geographic region	Global literature review
Structure Type	Artificial reefs
Stakeholders / sectors	NA
Social values explored	Does not explore values, but identifies 4 different 'uses' for artificial reefs: (i) tourism (scuba diving, recreational fishing, surfing and beach enhancement); (ii) fisheries; (iii) nature conservation (protecting what exists, mitigate unavoidable damage cause by infrastructure, restore damaged habitat to provide new community habitat); (iv) Science (audit the performance of reef, commercial species survey, epifaunal monitoring)
Methods:	What approach was adopted to engage stakeholders
	NA – no stakeholder engagement
	What approach was adopted to identify and evaluate social values
	NA Does however recommend an approach to ensure socio-economic objectives of ARs are realized: (1) assess the demand for artificial reefs (2) consult relevant stakeholders; (3) conduct a cost/benefit analysis; (4) decide whether to permit artificial reefs in the marine park; (5) involve stakeholders in the planning and management process; (6) set clear socio-economic goals and objectives; (7) consider social and economic issues in an appropriate management plan; (8) monitor and evaluate social and economic issues. (p 46)
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Contested objectives: Because of incompatibilities between gear and structure, placing an artificial reef on a seabed where commercial fishers operate can automatically exclude this group from the area that was formally open access and their 'right' to use (p. 45). Liability: Speculative questions regarding who is liable if accidents occur on AR or for property damage. In Australia, private citizens and interest groups can apply for artificial reef permits, and may be required to provide liability insurance for deployed structures p. 45
Other findings	Issues
	Stock increases: To date, artificial reefs have not proven to be an efficient restoration tool, neither when used for transplantation measures nor when left for natural recruitment (p. 41) Have the potential to lead to overfishing if they increase the aggregation/ attraction of existing stocks without increasing overall stock size (p. 45)
Other findings	Opportunities
	Structures: Artificial reefs can create or enhance recreational experiences: (i) add to the variety of fishing and/or diving experiences that exist within an area by providing different types of structure and attracting different kinds of marine life; (ii) provide more accessible fishing and diving opportunities when placed close to access points, thereby enabling people who are limited by experience, boat size/horsepower, time, or money to enjoy recreational fishing or diving; (iii) can enhance the recreational experience or success rate by attracting or producing more marine life and increasing the probability of observing and/or catching fish; (iv) can help redistribute use throughout a given area thereby reducing user congestion and crowding.

Thoughts/reflections	2: Identifies the social and economic uses of reefs, along with some of the potential conflicts that could arise. Good basis, but no stakeholder engagement, literature review only

Ref ID# 11	Andriesse 2018
Document type	Empirical research, peer-reviewed article
Title	Persistent fishing amidst depletion, environmental and socio-economic vulnerability in Iloilo Province, the Philippines
Summary	Article is concerned with the impact of environmental pressures on coastal livelihoods in the municipality of Ajuy, Iloilo Province, central Philippines. One of the three focuses of the research is on artificial reefs submerged to increase fish stocks. Specifically asked: Are the artificial reefs, submerged by the Red Cross in Ajuy Municipality in 2016 to increase fish stocks, likely to contribute to more sustainable fishing practices?
Geographic region	Iloilo Province, the Philippines
Structure Type	Artificial Reef
Stakeholders / sectors	Local fisher folk Key informants (unspecified)
Social values explored	Livelihood security and status, fishery productivity, perceptions of artificial reefs
Methods:	What approach was adopted to engage stakeholders
	Survey among 111 fisher folk households – the supposed future beneficiaries of the artificial reefs – and 19 semi-structured interviews with key informants Respondents for the survey were selected through snowball sampling as the survey was not meant for households that are not engaged in fishing. Questions pertained to their basic household structure, impact of the 2013 Typhoon Yolanda and the 2015–2016El Niño related drought, fishing practices (experience, selling or consuming, fisher folk associations activities), other livelihood options (land availability, employment of household members, remittances), their knowledge of and opinion on the newly installed artificial reefs, their opinion on relocation efforts by the government, standard of living before and after Typhoon Yolanda, as well as the major challenges in their community. The semi-structured interviews generated information on the institutional and political aspects of the artificial reef programme, the trade-off between fishing and non-fishing activities, local political tensions, and outlook on relocation efforts. The interviews also provided the opportunity to triangulate the answers with the survey data; to distil any inconsistencies and differences of opinions
	What approach was adopted to identify and evaluate social values
	Surveys and interviews
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Submerging artificial reefs created a positive perception of the future. There was now an expectation that fish stocks would improve in the medium term. But this expectation was not supported by evidence (see Issues below).
Other findings	Issues
	Perceptions/expectations: 'Not all presidents of fisher folk associations were informed about the reefs and only 31% of the respondents participated in seminars. This implies that 69% of the fisher folk do not have a precise idea of the functioning of the artificial reefs' (p. 134). In other words, potentially misplaced positive expectations on reef performance. Stakeholder expectations that the Municipality would enact an ordinance stipulating protection of reefs did not occur. Submerging prior to such an ordinance 'has created a serious issues' (p. 134)

	Responsibility: Lack of clear responsibility for monitoring and enforcing fishing rules on submerged reef, means illegal fishing difficult to stop without confirmed mandate.
Other findings	Opportunities
	Not stated
Thoughts/reflections	2: covers aspects of social value but not interrogated in detail. • Focus not entirely on MMI, but is one component of the study. • Specifically explores stakeholder's perceptions of submerged reefs. • Issues of management in already difficult/unmanaged fisheries raised.

Ref ID #1	Barclay et al 2017
Document type	Case-study research, peer-reviewed article.
Title	The importance of qualitative social research for effective fisheries management
Summary	Uses three case study research projects to demonstrate the value of social qualitative research in understanding and managing fisheries resources.
Geographic region	Case 1: Eastern Australia Case 2: Solomon Islands Case 3: Papua New Guinea
Structure Type	None – general fisheries assessments
Stakeholders / sectors	Case 1: Fishers and non-fishers such as members of local councils and community groups. Case 2: People selling fish and other marine products in markets; people from fishing villages; people from government and from non-government organizations (NGO) working on gender, conservation and fisheries management; employees and managers from tuna companies; community representatives, and people from villages. Case 3: fishers and customary resource owners, exporters in PNG, importers, wholesalers and retailers in China, key informant BDM researchers and staff of relevant government agencies in PNG (NFA, Customs, Provincial Fisheries Officers and other Provincial Government officials, and Local Level Government representatives)
Social values explored	Focus on Case 1: Well-being In the 3D wellbeing approach, the factors to consider are divided into material, relational, and subjective (or cognitive). Material wellbeing = income, assets, educational and health status. Relational wellbeing = social relationships people have that enable them to pursue their livelihoods or through psychological questionnaires about satisfaction with important relationships. Subjective wellbeing = quality of life people perceive themselves as achieving, including the meanings they give to the goals they achieve and the processes in which they engage. It has been measured by tools such as the Global Person Generated Index (GPGI).
Methods:	What approach was adopted to engage stakeholders
	Case 1: Not stated Case 2: Snowballing Case 3: Contacting relevant stakeholder groups
	What approach was adopted to identify and evaluate social values
	Focus is on Case 1 – as this is closest to our type of study. Case 1: Well-being approach: aim was to go beyond the Gross Value of Production (GVP) and uncover broader community perceptions of and values around commercial fishing. *Overall approach*: 1) qualitative interviews and document reviews; 2) questionnaires measuring the values of various stakeholder groups regarding the contributions of professional fishing to communities; and 3) a quantitative regional economic analysis. *Detailed approach*: started with ideas from the literature and then gathering data with

	open-ended interviews, asking fishers and non-fishers, such as members of local councils and community groups, what kinds of social benefits they saw arising from the fishing industry in their communities. Compared interview data with literature on assessing well-being and quality of life and identified areas of community well-being significant to case study area. Used outputs to structure remaining interviews. Then analyzed all interviews together established these indicators of contribution to well-being, mapped the interview data on the material/relational/subjective aspects of these indicators, existing government and industry data, and the economic part of the project, and designed questionnaires to measure some elements. Case 2: Gendered approach: to uncover the roles of women in fisheries value chains, and the opportunities and constraints they face. See paper for further details. Case 3: Governance analysis: to illuminate market and social factors affecting governance of the fishery, as well as assess the fit of management instruments to those market and social factors. Since the first major publication on interactive governance, Fish For Life (Kooiman et al., 2005), it has been applied as an analytical tool to many different fisheries internationally. The study was thus based on interviews and a desktop review. See paper for further details.
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Case 1: Key finding was that despite a widespread perception among recreational fishers in NSW that recreational fishing catches are better if professional fishing is excluded, the data clearly showed that if professional fishing were to disappear from areas of the coast, the utility of recreational fishers would be negatively impacted.
Other findings	Issues
	Not stated
Other findings	Opportunities
	Not stated
Thoughts/reflections	3: Good background, references to support statements on the importance of social research and its growth in marine resource management and conservation in the Introduction of the article. Several articles identified for further review – see snowballing tab in excel literature file. Provides a good basis to support selected approach to assessing social values from aquatic infrastructure.

	Chen et al 2013
Document type	Empirical research, peer reviewed article
Title	Recreational Benefits of Ecosystem Services on and around Artificial Reefs: A Case Study in Penghu, Taiwan
Summary	Article examines economic value of ecosystem services – ie Two non-market methods, the Travel Cost Method (TCM) and the Contingent Valuation Method (CVM), were used to estimate the recreational value of ARs in Penghu, Taiwan.
Thoughts/reflections	0: Marked for removal from review due to economic focus only

	Do Carmo et al 2011
Document type	Empirical research, peer-reviewed article
Title	Enhancing submerged coastal constructions by incorporating multifunctional purposes
Summary	An appropriate reef design in terms of 'surfability', i.e. the possibility to surf a wave, for the Leirosa beach, located to the south of Figueira da Foz, midway along Portugal's West Atlantic coast, has been investigated.

Thoughts/reflections	0: Marked for removal from review as looks only at the design parameters of the structure, no social value assessment component.

Ref ID# 19	Sutton and Bushnell 2007
Document type	Review article, peer reviewed publication
Title	Enhancing submerged coastal constructions by incorporating multifunctional purposes
Summary	Reviews the available socio-economic literature regarding the deployment, use, and management of artificial reefs, and aims to identify and understand potential socio-economic issues and information gaps surrounding deployment of artificial reefs in the GBRMP.
Geographic region	GBMP Eastern Australia
Structure Type	Artificial reef
Stakeholders / sectors	Multiple stakeholder groups with diverse and often conflicting values and opinions surrounding use of the park: artificial reef proponents (e.g. recreational and commercial fishing groups, diving groups, fisheries agencies, researchers, the aquatic industry, community groups, private businesses (eg dive operators)
Social values (or issues) explored	Enhanced recreational opportunities Potential for increased fish catch and overfishing Change in property and resource rights Potential for conflict between user groups. Liability
Methods:	What approach was adopted to engage stakeholders
	NA – literature review only
	What approach was adopted to identify and evaluate social values
	NA – literature review only
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Enhanced recreational opportunities Potential for increased fish catch and overfishing - has direct social and economic impacts including reduced fishing opportunities, lower quality recreational fishing experiences, negative economic impacts on the communities and businesses that support the commercial and recreational fishing industries, and diminished natural values of the GBRMP. Change in property and resource rights: placing an artificial reef on a seabed where commercial fishers operate can automatically exclude this group from the area that was formally open access and their 'right' to use. Potential for conflict between user groups: resulting from pressure on the newly developed AR site; or stock redistribution. Liability: Content 'word for word' as per Ammar 2009. No current issues so potential social impacts are speculative at present. Concerns on who is responsible for potential accidents and the release of AR permits.
Other findings	Issues
	Economic: significant financial costs associated with deploying and managing artificial reefs.
Other findings	Opportunities
	Economic: Impacts on local economies due to artificial reef use can be significant, i.e. indirect job creation and spending in the community. Planning and Management of AR: should include the following steps: (1) assess the demand for artificial reefs in the GBRMP; (2) consult relevant stakeholders; (3) conduct a cost/benefit analysis; (4) decide whether to permit artificial reefs in the marine park; (5) involve stakeholders in the planning and management process; (6) set clear socio-economic goals

	and objectives; (7) consider social and economic issues in an appropriate management plan; (8) monitor and evaluate social and economic issues.
Thoughts/reflections	2: Ammar 2009 article looks like a very close rip-off of this article published in 2007. Same content for both. Useful in identifying different stakeholder groups and their potential issues, but no specific assessment of the 'values' of these groups and how interrelate or clash.

	Lima et al 2019
Document type	Review, peer-reviewed literature
Title	Overview and trends of ecological and socioeconomic research on artificial reefs
Summary	Systematic literature review of artificial reef research, including 620 studies throughout the world from 1962 to 2018. The primary focus of this study was to examine long-term trends in research, focusing on ecological and socioeconomic questions, and to develop new research directions for this field.
Geographic region	Global review
Structure Type	"artificial reef," "artificial structure," "artificial habitat," "artificial sea-mount," "surf reef," "fish aggregating device" and "fish attracting device".
Stakeholders / sectors	NA
Social values explored	Review examined all elements of AR research. Here we focus on the outcomes of their 'social-economic' component of the review. Systematic literature review under 6 papers addressing 'social aspects'
Methods:	What approach was adopted to engage stakeholders
	Review found the following methods were adopted: Interviews, questionnaire, boat monitoring, databases, and photographic record. The articles with the focus on 'social benefits' and 'environmental perception' applied interview methods and likert scale. These papers were either captured in our systematic literature review or have been added to the snowballing list (i.e. 1 article by Fitzsimmons 2008)
	What approach was adopted to identify and evaluate social values
	NA
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	NA
Other findings	Issues
	A potentially useful quote: …. 'the socioenvironmental aspects of conflicts arising from installing artificial reefs have been neglected, due to the difficulty of developing interdisciplinary studies that involve communities directly affected by these structures' (p. 90).
Other findings	Opportunities
	The progress of artificial reef science …depends on a better understanding of settlement and production mechanisms of artificial structures base on the effects of anthropogenic activities. In addition, it is important to consider several legislative requirements for artificial reef implantation at local, national and international scale (p. 90)
Thoughts/reflections	1: Review article demonstrating significantly low volume of peer-reviewed literature looking at the social aspects of Artificial Reefs. Useful as supporting evidence for importance of social and transdiscplinary research in this area, but no direct examples of social values or their assessment .

Ref ID #3	Kirkbride-Smith et al 2013
Document type	Empirical research, Peer-reviewed article
Title	The relationship between diver experience levels and perceptions of attractiveness of artificial reefs – examination of a potential management tool
Summary	Explores how AR should be designed to maximize appeal to scuba divers. Used questionnaire survey to explore divers perceptions of artificial reefs in Barbados and examined reef substitution behavior among divers.
Geographic region	Barbados, West Indies
Structure Type	Artificial reef forms: sunken vessels and Reef Balls
Stakeholders / sectors	Recreational divers
Social values explored	Reef use, satisfaction and habitat preferences
Methods:	What approach was adopted to engage stakeholders
	36 question self-administered questionnaire exploring artificial reef use, awareness, satisfaction of AR diving and their habitat preferences. Likhert scales and checklists and 8 open ended responses. Distinction between the experience levels of divers was incorporated (i.e. < or >100 logged dives) Sampling conducted with assistance of diving companies.
	What approach was adopted to identify and evaluate social values
	Quantitative surveys
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	With increasing experience of divers, satisfaction level with AR declined. Fish abundance rated as the most important attribute of an artificial reef, followed by sea visibility, safety and coral cover. Shipwrecks were the most preferred AR (76%), followed by sunken vessels (15%) and piers, jetties or platforms (3%). Motives for diving were dominant by the reliability of the diving experience and associated biodiversity viewing and photographic opportunities.
Other findings	Issues
	Not stated
Other findings	Opportunities
	Not stated
Thoughts/reflections	3: Explores social values and preferences of one stakeholder group (divers) but only through quantitative methods.

Ref ID# 20	Tessier et al 2015
Document type	Empirical research, peer-reviewed literature
Title	Expectations of professional and recreational users of artificial reefs in the Gulf of Lion, France
Summary	In this work, the perceptions of AR professional and recreational users (direct users only) were studied by focusing on three AR sites located along the Gulf of Lion coastline (northwestern Mediterranean Sea, France) to determine whether they were becoming multi-use sites or were negatively perceived.
Geographic region	Three sites on the Gulf of Lion coastline (northwestern Mediterranean Sea, France): Agde, Valras and Leucate-Barcares
Structure Type	Artificial reefs, constructed from pipes and deployed on sandy-mud bottoms 1-2km from the coast

Stakeholders / sectors	Only incorporated direct users of the sites. Artisanal fishermen, Recreational fishermen, Recreational spear fishermen and SCUBA divers
Social values explored	Expectations of ARs, satisfaction with ARs, use levels, knowledge
Methods:	What approach was adopted to engage stakeholders
	Exhaustive sampling for users of small populations (artisanal fishermen and speak fishermen) and quota sampling for large populations (recreational fishermen, club and non-club members, and SCUBA divers).
	What approach was adopted to identify and evaluate social values
	Interviews were semi-directed (closed and open ended questions). Interviews designed for each target group, but with similar elements across the groups. Qualitative data was coded and analyzed as quantitative data.
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	The results of this study indicate that AR users have either neutral or positive perceptions regarding ARs. User groups were predominantly male. All users highlighted the goal of AR to increase fish populations and rated this goal as desirable. Different species recruitment priorities for commercial vs recreational fishermen. Using ARs to prevent illegal trawling was a desired goal for artisanal fishermen. Different satisfaction levels with the enhancement of fish around ARs, but valued their ability to support target species (ie spear fishermen and recreational fishermen. SCUBA divers were dissatisfied with AR design. Local recreational fishermen the most common users of the ARs
Other findings	Issues
	Not stated
Other findings	Opportunities
	Not stated
Thoughts/reflections	2/3: Intro section provides good summary of lack of research into socioeconomic features of ARs. Highlights differences in perceptions based for different user groups. Main finding is that while designed as mono-use (ie one stakeholder group) structures in France, they are being adopted by multiple user groups and therefore require greater management attention.

Ref ID #2	Belhassen, Y., Rousseau, M., Tynyakov, J., & Shashar, N. 2017
Document type	Peer reviewed Journal Article
Title	Evaluating the attractiveness and effectiveness of artificial coral reefs as a recreational ecosystem service
Summary	This paper evaluates the recreational benefits of artificial coral reefs for recreational divers. Artificial reefs are perceived as recreational ecosystem services. Artificial reef use is compared to natural reef use.
Geographic region	Eliat, Israel
Structure Type	Artificial reef e.g. shipwreck
Stakeholders / sectors	Recreational divers
Social values explored	Popularity of types of marine environments (natural and artificial) Recreational benefits of artificial reefs Self-perceived behaviour and attitudes towards types of marine environments

Methods:	What approach was adopted to engage stakeholders
	Qualitative and quantitative survey's distributed through recreational diving clubs and direct observation of recreational divers on artificial reefs
	What approach was adopted to identify and evaluate social values
	Study 1: Mixed method survey distributed through recreational diving Facebook group about skill level and diving sites frequented Study 2: direct observation of diving behaviour at natural and artificial marine sites Study 3: mixed methods questionnaires distributed at diving sites and online to examine recreational divers self-perceived behaviour and attitudes towards types of marine environments
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Large majority of divers use a mixture of natural and artificial reefs Though there are more natural reefs available an artificial structure was the most popular site Recreational divers are more likely to disturb (touch) an artificial reef than a natural reef Both new and independent divers caused damage to the artificial reefs Recreational divers feel more relaxed around natural marine environments Large majority of divers did not feel it was appropriate to touch either types of reefs Small percentage felt that it was appropriate to touch artificial reefs
Other findings	Issues
	Ensuring artificial reef structures remain popular for recreational use The functionality of artificial coral reefs is related to their ability to serve as a training site for introductory divers
Other findings	Opportunities
	Artificial reefs can be used as a distraction from natural marine environments ensuring ecological or sustainable functioning of natural reefs Introduction of pre-diving instructional videos for ALL recreational divers to minimise damage on artificial and natural reefs
Thoughts/reflections	3: specifically examines value of artificial marine infrastructure from multiple directions (frequency, self-report, and direct observation) within a identified group of interest for the FRDC study. Snowballing references found within article.

	Fabi & Spagnolo 2011
Document type	Edited Chapter Book
Title	**Artificial reefs in the management of Mediterranean Sea fisheries**
Summary	This book provides an assessment and synthesis of the role of artificial reefs in fisheries management. It also places emphasis on artificial reefs increasing impact on the environment and ecology. Individual papers within a book, collation of literature with a management and ecology focus.
Thoughts/reflections	0: removed from review. No in depth social value component rather focuses on management of artificial structures and the impact on the ecological environment.

	Feary, Burt, & Bartholomew, 2011
Document type	Peer Reviewed Journal Article
Title	**Artificial marine habitats in the Arabian Gulf: Review of current use, benefits and management implications.**

Summary	Article discusses the types of artificial reef structures that exist within the Arabian Gulf and explores challenges (from an ecological, economic, tourism and fishing activity perspective) and opportunities regarding future management of these reefs.
Thoughts/reflections	0: though it gives good background and could be useful in a broader sense is has no social component. Removed from review.
	Fernandez 2005
Document type	Peer Reviewed Journal Article
Title	A diversified portfolio: joint management of non-renewable and renewable resources offshore
Summary	This paper gives provides a stochastic control model grounded in ecological and economic theories for renewable and non-renewable infrastructure in relation to the oil and gas and fishing industries. It is said that this could help highlight decommissioning decisions relating to full removal or leaving the structures in place.
Thoughts/reflections	0: no social value, heavily focused on oil and gas industry economics and decommissioning decisions, removed from review

	Florisson, Tweedley, Walker, & Chaplin 2018
Document type	Peer Reviewed Journal Article
Title	Reef vision: A citizen science program for monitoring the fish faunas of artificial reefs
Summary	This study engages recreational fishers in a community to monitor fish populations at artificial reef structures using video technology placed under the boat. The study had two objectives the first to prove the effectiveness of citizen scientist programs and the second to use Baited Remote Underwater Video Systems (BRUVs) to monitor fish at two artificial reef locations.
Geographic region	Dunsborough and Bunbury, Western Australia
Structure Type	Artificial Reefs
Stakeholders / sectors	Recreational Fishers
Social values explored	Sense of stewardship/ownership of community on artificial structures
Methods:	What approach was adopted to engage stakeholders
	Participants were recruited via a science program called “Reef Vision” run by Recfish West
	What approach was adopted to identify and evaluate social values
	Not explicitly stated: effectiveness of the citizen science program and engagement in associated closed Facebook group
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Participant contributions were viewed as a way to give back to the community Creating a sense of satisfaction, contentment, achievement, fulfilment, pride and happiness This may increase ownership and stewardship over the artificial reefs
Other findings	Issues
	Large pool of volunteers may have been more effective for data collection
Other findings	Opportunities
	Study demonstrated that citizen science can be effective in studies exploring aspects of artificial reefs – could be applied in future studies
Thoughts/reflections	1: does not explicitly state that it is exploring social values or how inferences were made but mentions social values of stewardship and ownership

	Haddock-Fraser & Hampton 2012

Document type	Peer Reviewed Journal Article
Title	**Multistakeholder values on the sustainability of dive tourism: case studies of Sipadan and Perhentian Islands, Malaysia**
Summary	Paper explores the sustainability of dive tourism from the lens of interrelated pillars of sustainable development (economic, social and environmental) within two case studies on islands in Malaysia
Geographic region	Sipadan and Perhentian Islands, Malaysia
Structure Type	N/A (natural reefs)
Stakeholders / sectors	Dive instructors, dive businesses, non-dive businesses and tourists
Social values explored	Community development issues: cultural challenges at the site; impact of tourism on language; impact of large business investors; role of government
Methods:	What approach was adopted to engage stakeholders
	Semi-structured interviews exploring infrastructure development, tourist impacts, environmental impacts and community development within two case studies/locations
	What approach was adopted to identify and evaluate social values
	Transcripts put into NVivo and analysed for emergent stakeholder issues
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Perhentian: Non-dive business expressed negative feelings towards tourism development based societal changes Interviewees feel powerless to influence proposed development changes suggested by government e.g. proposal for expansions on resort hotels Sipadan: Non-dive business' were positive on community aspects that would relate to the economy Non-dive businesses, divers and locals expressed concerns over cultural differences e.g. attitudes towards modesty, religion and drinking
Other findings	Issues
	Concerns over government control of development not considering the wider community opinion
Other findings	Opportunities
	Social value related to economic value: engaging in community activities for the economic benefit
Thoughts/reflections	1: though it does not specifically explore MMI it mentions provides insight into social values due to develops associated with activities similar to those found on existing MMI. Also refers to the development of two jetties that destroyed diving sites in one case study.

Ref ID# 12	Hooper Ashley & Austen 2015
Document type	Peer Reviewed Journal Article
Title	**Perceptions of fishers and developers on the co-location of offshore wind farms and decapod fisheries in the UK**
Summary	Discussion surrounding co-location of offshore windfarms and fisheries. Perceptions of potential barriers and opportunities are given by fishers and developers and compared to current practices.
Geographic region	The UK
Structure Type	Offshore windfarms, decapod fisheries and artificial reefs
Stakeholders / sectors	Fishers and representatives of companies developing offshore windfarms

Social values explored	Access and licensing Artificial reefs as structural enhancers Previous experiences of fishing activities relating to artificial infrastructure Perceived harm of artificial infrastructure
Methods:	What approach was adopted to engage stakeholders
	Face-to-face semi-structure interviews using a questionnaire
	What approach was adopted to identify and evaluate social values
	Transcripts were evaluated for emergent themes themes
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Fishers either agreed or did not know if offshore windfarms would cause benefit or harm to fishing activities Main perceived effect of building offshore windfarms was loss of ground for fishermen Another perceived effect was loss or damage of gear Fishermen expected to receive financial compensation for disruption to fishing activity Co-location of infrastructure seems logical if managed properly Fishers and developers agree that artificial reefs would support fishing activity Developers have a clear preferences for licensing around infrastructure but fishers oppose to this practice
Other findings	Issues
	Concerns of gear getting snagged by infrastructure that would result in costs for fishermen and developers alike Fishermen have concerns about effects of noise of structures to marine like and displacement of fishing grounds
Other findings	Opportunities
	Developers seeking to build a relationship based on mutual understanding Fishermen expect to receive financial compensation for disruption to activities
Thoughts/reflections	2: article discusses some social values related to man-made marine infrastructure but is more focused on the impact of co-location of these structures with fisheries

Ref ID# 13	Hooper, Hattam & Austen, M 2017
Document type	Peer Reviewed Journal Article
Title	Recreational use of offshore wind farms: Experiences and opinions of sea anglers in the UK
Summary	This paper discusses and compares the impacts that offshore windfarms have or may have on the fishing activity of recreational anglers in the UK. The primary aim of this paper was to address the gaps in previous research addressing the same topic. Differences arise between perceptions of offshore windfarms and actual experiences with the structures.
Geographic region	The UK
Structure Type	Offshore windfarms
Stakeholders / sectors	Recreational anglers in the UK
Social values explored	Experiences angling within offshore windfarms Environmental/energy impacts of offshore windfarms
Methods:	What approach was adopted to engage stakeholders
	An closed and open ended online questionnaire exploring demographic information, fishing activity, experience with offshore windfarms and, environmental/energy impacts. Questionnaires were distributed by angling clubs and representatives of the Inshore

	Fisheries and Conservation Authorities.
	What approach was adopted to identify and evaluate social values
	Responses were analysed for agreeance or disagreement on a Likert scale while open ended question responses were analysed for emergent themes
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	No consensus on whether fishing activities would be impacted by offshore windfarms A small proportion felt that offshore windfarms would harm wildlife and the environment including impacts on: the view, noise disturbances, navigation and safety issues Perceptions from recreational anglers was generally positive however actual experience was a mix of positive and negative
Other findings	Issues
	Infrastructure would decrease the aesthetics of the environment
Other findings	Opportunities
	Infrastructure would provide a safe haven for fish from commercial fishers Infrastructure would help negate the impacts of climate change
Thoughts/reflections	2: paper explores opinions of one singular group and doesn't go in depth as to why this group have the opinions or values that they do but rather just state what their opinions/concerns/opportunities are

	Kantavichai et al 2019
Document type	Peer Reviewed Journal Article
Title	Small-scale fishery income impact from artificial reefs in Lang Suan District, Chumphon Province, Thailand
Summary	This paper studies the economic impacts of artificial reefs in Thailand providing estimates of how the artificial reefs have impacted the fishing communities incomes. Researchers also explore perceptions of fishers of whether they think that the reefs have positively or negatively impacted their incomes.
Thoughts/reflections	0: no social value, economic focus, removed from review

	Karm, 2008
Document type	Peer Reviewed Journal Article
Title	Environment and energy: The Baltic Sea gas pipeline
Thoughts/reflections	0: though the article has a sections for the 'Assessment of Political, Socioeconomic and Energy Implications' it is heavily focused of the politics and history of interactions between oil and gas companies and economic impacts of a potential pipeline. No stakeholder consultation was engaged in rather is article is an academic opinion piece. Removed from review.

Ref ID# 14	Kienker et al 2018
Document type	Peer Reviewed Journal Article
Title	Bringing harbours alive: Assessing the importance of eco-engineered coastal infrastructure for different stakeholders and cities
Summary	The aim of this study was to assess the attitudes and perceptions of people towards ecological engineering in four urban harbours, in which seawalls are the dominant artificial coastal structure. Findings differed based on stakeholder education levels and socioeconomic status.

Geographic region	Australia: Sydney and Hobart New Zealand: Auckland and Tauranga
Structure Type	Seawalls in coastal harbours
Stakeholders / sectors	Stakeholders were divided into: property and businesses, transport or work unrelated to the harbour, leisure and recreation, work directly associated with the harbour and work tied directly to managing or understanding the harbour.
Social values explored	Overall support for ecological engineering Concern for harbour environment Impact of prior knowledge on social values e.g. environmental concerns
Methods:	What approach was adopted to engage stakeholders
	Quantitative survey that was distributed using convenience sampling via through advertisements on community boards, business cards, emails, social media, newsletters, mailing lists, and in-person using face-face surveys in four suburbs along each harbor foreshore
	What approach was adopted to identify and evaluate social values
	Data was analysed using a generalised linear models with a binomial distribution
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Stakeholders whose work is associated with the harbour are more supportive of ecological engineering As income and education levels rise so does concern for the harbour Prior knowledge of the harbour did not impact attitudes towards ecological engineering People with prior knowledge of the harbour were more likely to respond positively to the idea of paying taxes associated with ecological engineering
Other findings	Issues
	Socioeconomic status can impact how artificial infrastructure is perceived
Other findings	Opportunities
	Increasing knowledge of artificial infrastructure may increase community monetary support of the structures via taxes
Thoughts/reflections	2: explores perceptions of ecological engineering but does not go in depth as to why. Not within an oil and gas setting. Snowballing articles found from paper.

	Kirkbride-Smith Wheeler & Johnson 2016
Document type	Peer Reviewed Journal Article
Title	Artificial reefs and marine protected areas: a study in willingness to pay to access Folkestone Marine Reserve, Barbados, West Indies.
Summary	This paper explores the economic value of artificial reefs and marine protected areas by measuring individuals willingness to pay for access to the two types of marine environments. Individuals are more willing to pay more for use of a natural marine environment over a artificial one.
Geographic region	Marine Reserve, Barbados, West Indies.
Structure Type	Artificial reefs
Stakeholders / sectors	Recreational snorkellers and divers
Social values explored	Visitors' perceptions of artificial reefs Reef material preferences Reef conservation awareness
Methods:	What approach was adopted to engage stakeholders

	Quantitative survey exploring demographics, diver history, snorkeling satisfaction, and a description of a hypothetical marine environment with payment options, questions about the type of organisation respondents would prefer the reef to be managed by, and questions about environmental awareness and general concern for the reef Informal focus group for recreational snorkelers and divers
	What approach was adopted to identify and evaluate social values
	SPSS used to analyse quantitative values
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Artificial reef awareness was higher than marine reserve awareness Majority of participants had 'good' or 'very good' experiences with artificial reefs Majority of participants were open to the development of a new artificial reef within the Folkestone Marine Reserve The most preferred artificial reef type was a shipwreck
Other findings	Issues
	N/A
Other findings	Opportunities
	Participants are willing to pay for access to artificial reefs Openness to future artificial reef development
Thoughts/reflections	1: focus on economic value rather than social value associated with willingness to pay. Some social value therefore left in review.

Ref	Kotowicz, Richmond & Hospital 2017
Document type	Peer Reviewed Journal Article
Title	**Exploring Public Knowledge, Attitudes, and Perceptions of the Marianas Trench Marine National Monument.**
Summary	This paper explores public social values regarding knowledge and awareness, benefits and impacts; management and governance, and variation in perceptions regarding the Marianas Trench Marine National Monument. This was achieved by using a telephone survey.
Thoughts/reflections	0: though the review discusses social value the national monument does not contain any man-man aquatic infrastructure. Removed from the review.

Ref ID #4	Kruse, Bernstein & Scholz 2015
Document type	Peer Reviewed Journal Article
Title	**Considerations in evaluating potential socioeconomic impacts of offshore platform decommissioning in California.**
Summary	This review explorers the socioeconomic impact of decommissioning options (complete or partial removal) on commercial and recreational fishers and recreational divers within the domains of access, marine resources, and preferred options of stakeholders. The paper suggests that socioeconomic impacts are influenced by a combination of ecosystem, commercial fishery, recreational fishery and scuba/dive values.
Geographic region	Southern California
Structure Type	Oil and Gas Platforms
Stakeholders / sectors	Commercial fishers, recreational fishers, recreational divers
Social values explored	Access Marine resources Preferred decommissioning options

Methods:	What approach was adopted to engage stakeholders
	Existing data sets were used therefore no stakeholder engagement was performed
	What approach was adopted to identify and evaluate social values
	PLATFORM decision support model's conceptual modelling tools
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Partial Removal *Access:* Take zone: marginally increase area for all users. No risk of collision for commercial fishers, commercial fishers who were concerned about snagging will still avoid areas, recreational fishermen and divers may now access the areas No-take zone: recreational fishermen and divers will have increased access but commercial fishermen will not *Marine Resources* No-take zones: increased access for commercial and recreational fishermen may contribute to regional maintenance of populations once targets by other types of fishing, unclear impact for recreational divers Complete Removal *Access:* fishermen and boaters will see marginal increase in accessible area, boats over 100ft will see larger increase due to elimination of safety zones, trawl and longline fisheries will see greatest increase as no risk of snagging equipment, recreational divers and fishermen see no benefit as they do not tend to use these areas, commercial fishers see no benefit as they use designated shipping lanes *Marine resources:* removal of habitat may negatively impact commercial fisheries production potential, minimal impact on recreational fishers, recreational divers lose opportunity to view wildlife Overall decommissioning preference: Commercial fishing: Trawlers, purse seiners, longliners: complete removal Fixed gear: partial Recreational fishing: partial Recreational diving: Partial Recreational boating: none Commercial shipping: none
Other findings	Issues
	Stakeholder groups have different preferences for decommissioning options for different reasons which can make decision making regarding removal of oil and keeping multiple communities happy
Other findings	Opportunities
	Collaboration opportunity
Thoughts/reflections	3: explores social values within a causal model framework involving multiple stakeholder groups. Potentially provides a way of looking at existing data.

Ref ID# 15	Lima et al 2018
Document type	Peer Reviewed Journal Article
Title	Artisanal fisheries and artificial reefs on the southeast coast of Brazil: Contributions to research and management.

Summary	This study explored the populations of fish found on a artificial reef if Brazil as reported by local commercial fishermen. Perceptions of the role the reef has on the fish ecology is also explored.
Geographic region	Guaxindiba, Brazil
Structure Type	Artificial Reefs
Stakeholders / sectors	Artisanal Fisheries (commercial fishermen)
Social values explored	Perception of artificial reefs: their roles, uses, and influence Particularly in relation to the fish populations themselves
Methods:	What approach was adopted to engage stakeholders
	Semi-structured mixed methods interviews using snowball sampling
	What approach was adopted to identify and evaluate social values
	Interview responses organised into quantitative categories Fishermen perception was analysed through the triangulation method: crossing information collected through field diary, participant observation, and interview-questionnaire
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Most fishermen were aware of the artificial reef and its location Majority of fishermen use the AR to fish Fishermen associated 24 fish species with the AR (15 of which not previously found in that area) Fishermen stated that Ars were useful for fish feeding, breeding and shelter
Other findings	Issues
	N/A: fishermen reported that the AR structure did not create any conflicts
Other findings	Opportunities
	Ars are seen as having a positive impact on local fishing Increase in catch abundance and species richness
Thoughts/reflections	2: though some social values are discussed the studies primary focus is the populations found/ecological makeup of the reefs as perceived by commercial fishermen

	Mangano, & Sarà, 2017
Document type	
Title	**Collating science-based evidence to inform public opinion on the environmental effects of marine drilling platforms in the Mediterranean Sea.**
Summary	This study completed a systematic literature review to create a evidence map to be used to inform public opinion informing the question 'what effects do offshore extraction platforms have on the Mediterranean marine ecosystem components?' This map was to be used at the beginning of public consultations.
Thoughts/reflections	0: no social value except for a line at the end that states that this form of research can be used to 'drive decision- makers, stakeholders and public opinion in taking evidence- based decisions.' Removed from review.

	Munsch, Cordell, & Toft, 2017
Document type	Peer Reviewed Journal Article
Title	**Effects of shoreline armouring and overwater structures on coastal and estuarine fish: opportunities for habitat improvement.**
Summary	This article examined literature exploring the impacts of costal structures on estuarine fish. It was determined that there are differences in fish population and behaviour when

	comparing armoured and unarmoured shorelines and structures. It is suggested that further research and management into these structures within human-use constraints may be beneficial.
Thoughts/reflections	0: ecological focus , no social value researched, limited mention of 'human use constraints' but is not the focus of the study removed from review

Ref ID #5	Murray & Betz 1994
Document type	Peer Reviewed Journal Article
Title	User views of artificial reef management in the southeastern US.
Summary	This article explores the views of recreational fishers and divers, environmentalist and commercial fishers on artificial from the perspectives of general use and knowledge, administration, sitting/construction, funding, information, evaluation, and conflict resolution. Researchers find both differences and similarities across user groups and locations depending on topic being discussed.
Geographic region	North Carolina, Florida, and Texas USA
Structure Type	Artificial Reefs
Stakeholders / sectors	Recreational divers and fishers (sportsdivers and sportsfishermen), environmentalists, commercial fishers
Social values explored	general use and knowledge, administration, sitting/construction, funding, information, evaluation, and conflict resolution
Methods:	What approach was adopted to engage stakeholders
	A quantitative questionnaire that included 8 sections: I) general knowledge and use, 2) administration, 3) funding, 4) siting/construction, 5) information, 6) evaluation, 7) conflict resolution and 8) a user profile. The questionnaire was distributed via the mail and stakeholder communities were accessed via respective clubs they were involved in
	What approach was adopted to identify and evaluate social values
	Quantitative methods were used to assess % of responses on the Likert scale or rankings of perceived views
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	General use and knowledge Majority of respondents were very or somewhat familiar with their local artificial reef Environmentalists had the lowest familiarity Top ranked perceived benefit of an AR was to increase the number of fishing locations, second was provides fishing/diver closer to home – importance of access Respondents perceived Ars as important for removing fishing pressure from natural reefs and increasing fish productivity Commercial fishing was seen as the least relevant benefit Overcrowding was viewed as an issue found at ARs Administration User community is satisfied with how the AR is run No significant difference in satisfaction across user groups other than commercial fishermen who were more likely to be dissatisfied Funding User groups favoured the use of a stamp to fish/dive program on artificial reefs Majority of user groups were willing to pay $5 or $10 to use ARs

	Sitting/construction Offshore reefs (12 miles offshore) ae the most preferred ARs Most popular ARs are made from ships or barges while the second most popular are obsolete oil rigs **Information** All user groups except commercial fishermen reported newsletters as their primary source of AR information Club meetings, newspapers and magazines were also ranked as important **Evaluation** Users willing to serve on an advisory committee outnumbered those who would not 50.6% of participants indicated that they would assist in data collection about fishing and diving activity – recreational divers and fishers more so than commercial fishers or environmentalists **Conflict resolution** Majority of users had no experiences conflict Most reported conflict was as a result of overcrowding
Other findings	Issues
	Overcrowding or overuse at AR locations leading to conflict Environmentalists concerned about negative impacts on biological community as a result of overfishing and pollution Agencies that maintain/manage ARs do not do a good job informing the public about artificial reef activities
Other findings	Opportunities
	Artificial reefs provide additional fishing locations Issue relating to ARs were agreed to less or seen as less of an issue than the benefits Stakeholders willing to donate their time and energy in assisting reef management and maintenance
Thoughts/reflections	3: explores multiple social value of multiple user groups. Fits well with scope of current research. Snowballing papers found from paper.

	Ng et al 2013
Document type	Peer Reviewed Journal Article
Title	**Seeking harmony in coastal development for small islands: Exploring multifunctional artificial reefs for São Miguel Island, the Azores**
Summary	This paper determines “optimal” MFAR multifunctional design criteria based on current progress and assessment of nine international MFARs installed to-date. It subsequently explores MFAR feasibility in São Miguel Island, the biggest and most populated Azorean Island with the largest surfing population. An assessment of surf breaks was undertaken, including coastal processes and retreat rates, and MFAR site selection, criteria and rationale are discussed
Geographic region	The Azores is a remote archipelago rich in the middle of the North Atlantic Ocean
Structure Type	Multifunctional artificial reefs (MFARs)
Stakeholders / sectors	None
Social values explored	None
Methods:	What approach was adopted to engage stakeholders
	None
	What approach was adopted to identify and evaluate social values
	None

Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	No social values explored, although notes some 'values' artificial reefs provide: i.e. reduced coastal erosion, surfing tourism, amenity value via beach widening.
Other findings	Issues
	Poor construction, imprecise location, can cause negative outcomes, i.e. reduced surfing quality
Other findings	Opportunities
	One quote that provides more support for the need for social assessments: "More emphasis needs to be given to social perceptions of the reef (e.g. locals, tourists, surfers, beach-goers, divers, fishermen) and socio-economic studies to consider regional economic return (e.g. local businesses, tourists, lodgings, property value).: p. 106
Thoughts/reflections	1: Focus is on the geomorphic and oceanographic conditions for a 'good' artificial reef. Only minor reference to the social value that can also be gained through MFARs.

	Ocke 2016
Document type	Review, Peer Reviewed Journal Article
Title	Management recommendations of artificial reefs for practice of surfing
Summary	This study aims to present a set of recommendations that may contribute to public and private managers who plan to include the deployment of artificial reefs focusing on surfing conditions improvement in many localities. Therefore, this exploratory qualitative research runs from a brief literature review on the subject and a multiple case study - Australia, USA, New Zealand, India and England - to support the reasoning.
Geographic region	Multiple case study - Australia, USA, New Zealand, India and England
Structure Type	Artificial reef
Stakeholders / sectors	Surfing
Social values explored	Not explored
Thoughts/reflections	0: Exclude as not in English (Spanish I think??) Conclusion from abstract suggests its coverage of social values would have been limited anyway. "The results included the innovative nature of this type of structure, requiring a steady improvement in the construction and management methods, long-term monitoring programs to assess effectiveness, challenges in integrating users, public participation in different stages along the process, appropriate expectations management of the shareholders."

Ref	Oh, Ditton and Stoli 2008
Document type	Empirical research , Peer Reviewed Journal Article
Title	The Economic Value of Scuba-Diving Use of Natural and Artificial Reef Habitats
Summary	This article addresses the question of whether artificial reefs are functionally acceptable to scuba divers. Research objectives were (1) to identify the nonmarket value of recreational scuba diving in offshore marine waters and (2) to ascertain whether the willingness to pay for scuba diving varied between users of natural and artificial reef habitats.
Geographic region	Texas offshore waters, US
Structure Type	Artificial reefs
Stakeholders / sectors	Divers
Social values explored	Differentiating use values of natural and artificial reefs in the same area.
Methods:	What approach was adopted to engage stakeholders

	Survey, respondents approach via dive charter operators records
	What approach was adopted to identify and evaluate social values
	Economic valuation only
Findings	**Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]**
	Satisfaction levels: Explored satisfaction levels of reef divers versus artificial reef divers. Found reef divers more satisfied.
Other findings	**Issues**
Other findings	**Opportunities**
	MPAs in the future may need to include artificial reef habitats to help redistribute scuba diving use and give heavily used areas time to recover. Apparently, artificial reefs are not the ''junkyards of the ocean'' as some have suggested previously, but rather, they have value to their users and offer an opportunity to reduce pressure on natural reefs through wise management while producing additional human benefits perhaps not otherwise possible.
Thoughts/reflections	1: Focus is on economic value, a couple of statements identified that refer to the management benefits afforded by the inclusion of ARs. These are included above under 'opportunities'.

	Oliveira et al 2015
Document type	Empirical Research, Peer Reviewed Journal Article
Title	**An approach to the economic value of diving sites: artificial versus natural reefs off Sal Island, Cape Verde**
Summary	In the present paper there was a twofold hypothesis, i.e. that the deployment of artificial reefs adds value to natural features by diversifying diving sites and thus be a certain propensity concerning the type of added value (either of non-extractive direct or indirect use). The objective was to ascertain to what extent artificial reefs deployed off Sal Island (Cape Verde) contribute to the local economic value by specifically providing alternative sites for recreational divers.
Research Type	Empirical research
Geographic region	Sal Island (Cape Verde)
Structure Type	Artificial reef – sunken vessels
Stakeholders / sectors	Divers,
Social values explored	Indirect values – species colonisation, creation of new dive sites, reduced pressure on natural reefs
Methods:	**What approach was adopted to engage stakeholders**
	None – stakeholders not engaged
	What approach was adopted to identify and evaluate social values
	None – economic value assessed only.
Findings	**Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]**
	Not stated
Other findings	**Issues**
	On the demand side, artificial reefs are not as appealing to divers
Other findings	**Opportunities**
	Not stated in relation to social values

Thoughts/reflections	0: Focus is on economic valuation – suitable reference for Johanna.

	Ounanian et al 2012
Document type	Empirical research Peer Reviewed Journal Article
Title	On unequal footing: Stakeholder perspectives on the marine strategy framework directive as a mechanism of the ecosystem-based approach to marine management
Summary	This article concentrates on five marine sectors active in the marine environment (fisheries, offshore renewable energy, offshore oil and gas, navigation, and coastal tourism) and on non-industry stakeholders represented by environmental Non-Governmental Organizations (eNGOs) and how they have engaged in the Marine Strategy Framework Directive (MSFD) stakeholder consultation process and what they foresee as potential challenges for implementation.
Geographic region	EU
Structure Type	None, exploring stakeholder perspectives on a EU marine policy
Thoughts/reflections	0: Not in scope, does not address offshore marine infrastructure or related social values.

Ref ID# 16	Pike et al 2010
Document type	Empirical research, Peer Reviewed Journal Article
Title	Social Value of Marine and Coastal Protected Areas in England and Wales
Summary	This article argues the need for a clearer, shared understanding of the social value of protected areas in creating new designations and managing existing ones. Social value reflects the complex, individual responses that people experience in a given place. Many reasons determine why one area is valued above another, and this research investigates the social value of MCPAs from a practitioner's perspective through a series of interviews.
Geographic region	England and Wales
Structure Type	None – focus on MPAs, but included given the explicit focus on social values.
Stakeholders / sectors	Managers and others with role in MPAs
Social values explored	Stakeholder definition of social value and the attributes that they believe contribute to the social value of MPAs. Categorised under 9 groups: Management, natural environment, spirituality, activities, community involvement, research etc, built infrastructure, access, marketing & promotion.
Methods:	What approach was adopted to engage stakeholders
	Selected representative MCPAs from international, European, national, regional, and local levels that were either statutory or non-statutory and marine with coastal boundaries or terrestrial with coastal boundaries. Interviewee selection was determined partly by the designation and partly by geographical location within England and Wales. Interviewees were also selected for their specific working experience within protected areas. There are many hundreds of people working within MCPA designations in England and Wales. In consideration of this, the main agencies responsible for MCPAs, including Natural England (NE), Countryside Council for Wales (CCW), as well as the Joint Nature Conservation Committee (JNCC) were phoned in the first instance and then contacts suggested by them were followed up until appropriate candidates were established.
	What approach was adopted to identify and evaluate social values
	Twenty-four semi-structured, telephone interviews with MCPA practitioners were conducted for the study and sought to identify what practitioners understand by social value within their MCPA and activities that encouraged or discouraged it. The interviews were analyzed using techniques consistent with grounded theory. These included memos and diagrams that helped with data organization and conceptualization, and coding that helped to sort, relate, and to continue to develop data categories in terms

	of their various properties, with final integration of key concepts. Data themes were assigned during analysis of the interview transcripts where direct comments were made. As analysis became more detailed sub-themes were applied and inferences were noted and also assigned a category. Interconnections in the data were noted and pertinent quotes from the interviews supporting the results were also recorded.
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Key themes of social value in MCPAs **Management:** The organization's reason for interest in environmental qualities and features: ecological interest scored highest with a significant decrease to spirituality, placing far less organizational interest in this area **The natural environment:** natural environment provides a strong and inextricable link to the social value of a MCPA and interviewees cited the natural environment as the main reason they understood for people visiting these areas. The dynamic nature of the coastal environment causes change in people's use patterns and the value of the area. **Spirituality:** can be considered on one level as a sense of place that can be experienced collectively or individually and is essentially an emotional connection that develops between people and their environment. Although spirituality was assigned a low score according to how interviewees felt their designating body viewed it, the interviewees themselves throughout the research made associations to the importance of spirituality in connection with social value. This disparity reinforces the need for a shared understanding of all social values effecting MCPAs if a full and effective contribution to MCPA development is to be made. **Activities:** ability to engage in recreational and educational activities directly contributed to social value. But increasing or adding activities within a MCPA did not necessarily increase its social value. Nearly half the interviewees felt their site had no capacity to do this anyway. Rather than increasing activities, interviewees discussed various ways of improving existing ones by better and more sustainable management and by widening the target group to include under represented members of the public **Community involvement**: Voluntary approaches to community work and inclusion of under-represented groups of people from the community were specifically mentioned. **Research, education, and interpretation** **Built infrastructure** **Access** **Marketing and promotion**
Other findings	Issues
	Not addressed
Other findings	Opportunities
	Generated a 'statement of best practice' which provides examples of the aspects that contribute to social value of MCPAs. For example: Management: Experienced, innovative staff; Reliable annual budget; Sustainable goals; Management plan; Enforceable regulations/Codes of conduct Health and safety; Site wardens; Study and analysis of management pressures; Collaboration with other managers in the area; Forecasting impacts of coastal dynamics and implications to recreational use of the coast Nature: Diversity of habitats and environmental features; Rare species, birds and wildlife; Good view points of land or seascapes; Coastal; Natural beauty For remainder of list see pg 427 in paper. Also developed a conceptual model to represent the key criteria contributing to social value. Very basic, natural environment and management in the middle, with the other elements (ie activities, spirituality etc) contributing to social value.

Thoughts/reflections	2: While focus is on MPAs (not offshore marine infrastructure), the introduction/rationale component of the paper would be useful when emphasising the value of social research in our context. The highlighted text provides example of what workshops could focus on, as opposed to 'issues and opportunities' as per the first workshop. The methods may be useful in considering how social values have been collated and represented.

	Polnac et al 2006
Document type	Peer Reviewed Journal Article
Title	Toward a model for fisheries social impact assessment
Summary	The Office of Science and Technology of NOAA's National Marine Fisheries Sevice invited a group of marine fisheries social scientists with expertise in social science modeling, quantitative methods, and marine fisheries impact assessment to create a conceptual model for predicting the social impacts of fishery management action alternatives using a limited set of quantitative and qualitative indicators. This paper presents the results of the first phase of this group's work. Well-being was selected as the dependent measure for marine fisheries social impact assessment in this model. While this model is not the only possible approach to social impact assessment, it does open a door to a room that is closer to those currently occupied by marine fisheries economists and their biologist counterparts.
Geographic region	United States
Structure Type	None
Stakeholders / sectors	None – framework involving engagement is presented
Social values explored	The SIA model for marine resource management is designed to predict changes in well-being (ie individual or group characterized as being healthy (sound and functional), happy, and prosperous).
Methods:	What approach was adopted to engage stakeholders
	Expert input for model development
	What approach was adopted to identify and evaluate social values
	Initial assessment identifies the critical populations that have a significant stake in the management action and the issues of concern to these populations that may increase or decrease their well-being. Next step following the scoping process is to operationalize the relevant variables by defining the variables in a way that facilitates measurement More important than simply identifying variables, however, is discerning the relationships among them
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	The model proposes aspects affecting well-being and potential interrelationships between them (ie external forces, management, activity attributes, activity satisfaction, social problems, individual attributes, social and community attributes). But does not provide applied examples, only theoretical examples for commercial fishers, recreational fishers, & subsistence fishermen.
Other findings	Issues
	Not applied, and refers to the need for extensive data to populate the model which does not currently exist and would require significant investment from managing authorities.
Other findings	Opportunities
	Suggest that the model provides a comparable assessment framework as per economic assessment, but does not demonstrate how this is achieved.

Thoughts/reflections	1: Not very useful, a general model from which potential attributes influencing well-being could be drawn, but does not explicitly consider stakeholders values in relation to offshore marine infrastructure.

Ref	Ramos et al 2019
Document type	Empirical Research Peer Reviewed Journal Article
Title	Local fishermen's perceptions of the usefulness of artificial reef ecosystem services in Portugal
Summary	Proponents of artificial reef (AR) deployment are often motivated by the usefulness of such structures. The usefulness of ARs is related to their capability of providing ecosystem services/additional functions. We present two distinct Portuguese AR case studies: (1) The Nazaré reef off the central coast of Portugal and (2) the Oura reef off the Algarve coast. Semi-structured interviews were conducted with local fishermen in the fishing towns of Nazaré and Quarteira pre-and post-AR deployment. The main focus of the interviews was to understand fishermen's perception of AR usefulness (or lack thereof) in terms of nine ecosystem services/additional functions potentially provided by the ARs.
Geographic region	Portugal
Structure Type	Artificial reefs
Stakeholders / sectors	Fishermen
Social values explored	Main focus of the interviews was to understand fishermen's perception of AR usefulness (or lack thereof) in terms of nine ecosystem services/ functions potentially provided by the AR (food production, recreation, biological control, nutrient cycling, disturbance regulation, reuse of obsolete structures, habitat and refuge, diversion effect, biodiversity preservation).
Methods:	What approach was adopted to engage stakeholders
	Not stated, only states that 'the potential survey population for this questionnaire included all fishermen who participate in fisheries that are generally prosecuted adjacent to the ARs.'
	What approach was adopted to identify and evaluate social values
	Survey questionnaires were conducted with local fishermen in the fishing towns of Nazaré and Quarteira pre-and post-AR deployment.
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	No specific social values or interrelationships explored. Focus was on examining perceptions of the utility of AR pre and post deployment, with the intention of highlighting the importance of understanding perceptions, and community expectations of AR outcomes, to ensure alignment between expectations and possible benefits to stakeholders.
Other findings	Issues
Other findings	Opportunities
	Methodological issue but overall benefit of AR: there is a possibility that some of the respondents were queried both before and after deployment. However, since the interviews conducted for this study were anonymous, we cannot confirm which respondents were queried twice. Although this limits further statistical analysis, interviews with the same respondent pool in both the pre- and post-deployment data collections were not possible given the 14 years between studies. Despite this limitation, this study shows that, generally, fishermen across both case studies had a range of expectations of the ecosystem services and benefits that ARs will provide. Likewise, they reported having benefited to some extent from a range of ecosystem services post-deployment.
Thoughts/reflections	1: While ecosystem services can align to social values, this paper does not go into detail regarding the values of the stakeholders in relation to the ARs – rather it examines

	stakeholders perceptions of the ability of AR to deliver specific ecosystem services, without asking if these ecosystem services are important or valued by the stakeholders.

	Ramos et al 2011
Document type	Empirical Research, Peer Reviewed Journal Article
Title	Stakeholder perceptions of decision-making process on marine biodiversity conservation on sal island (Cape Verde)
Summary	In order to allocate demand for diving and fishing purposes, we have developed a socio-economic research approach addressing the theme of biodiversity and reefs (both natural and artificial) and collected expectations from AR users by means of an inquiry method. Scrutinized stakeholders' perception on the best practice for marine biodiversity conservation in the Sal Island.
Geographic region	Cape Verde (Islands off the African coast)
Structure Type	Artificial reef
Stakeholders / sectors	1) Biologists, 2) Diving operators (DOs), 3) Non-governmental organizations (NGOs), 4) Managers, and 5) Recreational divers (RDs).
Social values explored	Stakeholder values were not explicitly explored, rather, their management preferences were evaluated (i.e. sinking artificial structures, restocking living organisms, raising community awareness or limiting threatening activities).
Methods:	What approach was adopted to engage stakeholders
	Targeted specific stakeholder groups directly, (ie approaching management authorities and local NGOs).
	What approach was adopted to identify and evaluate social values
	Questionnaire using the Analytic hierarchy process that asked to give their opinions, by means of a simple AHP methodology, about a future project aiming at marine biodiversity conservation on Sal Island and their preference regarding the allocation of money for each type of diving site, in the light of four different management options. Respondents were then asked to rank their preferred management measures. AHP = Individual experts' experiences are utilized to estimate the relative magnitudes of factors through pair-wise comparisons. Each of the respondents has to compare the relative importance between the two items under special designed questionnaire (from Wiki – clearer definition than available in paper).
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	No specific social values explored, however, the method adopted provides information on the variability or consistency in management option preferences across stakeholder groups which can be useful in understanding the potential support for management actions.
Other findings	Issues
	Not applicable
Other findings	Opportunities
	Not applicable
Thoughts/reflections	1: As stated, explores the management preferences of different stakeholder groups, and the AHP process presented might be useful in our context, but otherwise the paper provides limited contribution to understanding the range of social values or their assessment in relation to offshore marine infrastructure.

Ref ID #7	Ramos et al 2011b
Document type	Peer Reviewed Journal Article

Title	STAKEHOLDER ANALYSIS IN THE PORTUGUESE ARTIFICIAL REEF CONTEXT: WINNERS AND LOSERS
Summary	Presents the results of a stakeholder analysis in relation to an artificial reef program in Algarve. Stakeholders' interactions with the ARs were studied, along with their likely attitudes and behaviour towards the man-made structures. All stakeholder clusters were classified according to their expected degree of involvement throughout the different AR stages. The purpose of this stakeholder analysis was to find out winners and losers connected with the reef deployment.
Geographic region	Algarve (Southern Portugal mainland
Structure Type	Artificial reef
Stakeholders / sectors	Local fleet users, non-users, coastal fleet users, non-users, fishermen associations, fishermen producers org, charter boat anglers, offshore anglers, anglers clubs and associations, dive operators, spear-fishermen, offshore-aquaculture, fisheries research institute, directorate for fisheries, directorate for the environment, ports authority, financial institutions, navy, university, city councils. environmental agencies.
Social values explored	Policy goals explored, including: PRIMARY GOALS (1) to protect juvenile fish, especially those ones having higher commercial value (2) to promote biodiversity and allow the diversification of catches, (3) to contribute to the recovery of coastal fish resources, 4) to create fishing areas and promote a controlled exploitation of coastal fishing resources, 5) to develop a sustainable exploitation (6) to reduce fishing costs, and strategy, 7) to promote alternative fishing management measures. SECONDARY GOALS (1) to promote off-shore aquaculture, (2) to carry out fish enhancement/restocking actions, (3) to develop reef-related eco-tourism activities, (4) to develop integrated studies of coastal ecosystems functioning.
Methods:	What approach was adopted to engage stakeholders
	Several methods. In the first instance semi-structured questionnaire-based interviews were conducted to discover potential AR users, and (2) seminars were given in three fishing communities to promote structures among fishermen and obtain feedback from those that expressed interest in the ARs. A second instrument used was a questionnaire survey, intending to widen the range of stakeholder types, including not only primary stakeholders (i.e. AR users or potential users), but also secondary and external stakeholders (i.e. AR non-users). Additional instruments based on secondary data were also used including documentary sources such as research archives (e.g. electronic files from the Fisheries Directorate - DGPA) and content analysis (e.g. newspapers and internet pages). A stakeholder analysis on a regular basis is necessary because stakeholders' influence is not static.
	What approach was adopted to identify and evaluate social values
	The first phase the most important goals and purposes of the AR program were identified - goals that were perceived to have direct usefulness to people. IPIMAR developed seven primary and four secondary goals for the AR program, most of them focusing on biological (benthos and ichthyology) and oceanographic functions. In the second phase a list of all the different parties that revealed any interest in the developments was drawn up, i.e. stakeholders (i.e. primary, secondary and external). The third phase consisted of determining the interests of the different stakeholders. The stakeholders identified were questioned about their interests concerning the different policy objectives of the program. The data sources were: initial interviews with commercial

	fishermen and recreational users (anglers and divers), a questionnaire survey (RAMOS et al., 2007), and informal meetings. The fourth phase considered the impact of the project on each stakeholder, and also the influence or power each stakeholder wielded on the program according to their own interests and influence on the project outcomes [but how this was undertaken is not specifically stated].
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Experience shapes values – Primary winners and losers: Primary stakeholders' interest was triggered by the experiences they encountered when using the reefs. If they enjoyed good outcomes when they used the reefs, they will repeat the experience. Losers were the ones that due to reef deployment were expelled from the reef area or suffered operational limitations (e.g. some purse seine owners). For instance, secondary stakeholders such as IPIMAR achieved a higher reputation among stakeholders by delivering the program along its stages. **Secondary benefits:** External stakeholders such as local City Councils were winners because they gained in terms of job creation both during the construction of the ARs and as a consequence of primary stakeholder gains. In their turn, losers were all those who lacked confidence in the stability of the materials used in the construction of the ARs and/or believed that some habitat was destroyed or lost for a certain number of species (e.g. flatfish).
Other findings	Issues
	Empirically stakeholders judged ARs in their own interests and evaluated them according to their needs. In this stakeholder analysis it seems that those stakeholders to whom AR deployment has impacted negatively do not pose a threat to the success of the AR program.
Other findings	Opportunities
	Overall, the aggregated results show that most stakeholders are optimistic concerning the main objectives of AR policy and find them a useful way to invest in the marine environment, principally as a way of mitigating fishing problems and amplifying the economic value of the coastal area.
Thoughts/reflections	3: Provides an approach to explore the different values of stakeholder groups, linking values to the management goals. Benefits and limitations of the approach summarised as: "Through the simple stakeholder analysis an overall picture of stakeholder positioning about ARs from pre-deployment and throughout the lifetime of the project is possible. The main weakness of this approach is that for it to be adequately detailed is a time consuming task." p 142

Ref ID# 17	Ramos et al 2006
Document type	Empirical research, Peer Reviewed Journal Article
Title	**The usefulness of the analytic hierarchy process for understanding reef diving choices: a case study**
Summary	The main objective of this paper was to test the usefulness analytic hierarchy process AHP in identifying the conditions influencing divers' choice of dive sites. Decision makers need to know what role artificial reef modules play within the diving choice spectrum in order to decide their potential management interests, and AHP results can be used in that decision.
Geographic region	Algarve region of Portugal
Structure Type	Artificial reefs
Stakeholders / sectors	Diving
Social values explored	Examined how diving preferences determine the use of different dive sites, e.g. seeing unusual aquatic organisms, the benefits of updating diving skills.

	Biological diversity, geographic characteristics (depth, topography), dive atmosphere (water clarity etc), economic aspects (cost), dive motivations (diverse sites, updating skills, explore known site).
Methods:	What approach was adopted to engage stakeholders
	Not stated
	What approach was adopted to identify and evaluate social values
	Survey designed based on information obtained from a diving school to set questions exploring: (1) the beneficiaries (SCUBA divers); (2) the goal (choosing the best diving spot); (3) the criteria (relative factors to consider during the choice process); and (4) the alternatives (the different types of reef sites, which are prioritized). The value tree divided into A) the upper part of the tree, which aimed to establish the criteria taken into account by divers to go diving, and the relative importance of these criteria in order; and (B) the lower part of the tree, which identifies the choice options amongst five different diving site alternatives.
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Ecological diversity: divers' preferences indicate that divers attach the highest importance to the biological criterion, particularly the possibility of seeing an unusual fish or other less common aquatic organism. Conservation value of the dive spot also highly ranked in divers' choices. Personal development: The incentive to update diving skills or progress in scientific knowledge through diving discoveries was considered to be the second best sub-criteria that encourages people to dive. Facilities: Facilities provided by the hired service were also highly ranked in divers' choices. Site physical characteristics: geographic (0.070) and atmospheric (0.082) criteria seemed to be not as important for divers, and their respective sub-criteria always had a low elicited weight (always < 5% of the value in each of the choices). Surprisingly, species biodiversity (0.042) and visibility (0.044) were the least important as sub-criteria. Site Type: Divers preferred natural reefs, followed by archaeological spots . All the others ranked far below, with the artificial reef concrete modules being the least preferred choice.
Other findings	Issues
	While concrete artificial reef modules can be beneficial for local and recreation- al fishing, this exploratory study suggests that there are still questions over their importance for diving purposes. p 217
Other findings	Opportunities
	Given that the attributes of diving sites that attract divers are not unique to natural reefs, there may be scope in the future to divert diving choices towards artificial habitats, whether these be accidental (e.g., shipwrecks) or intentional structures (e.g., sunk vessels), in order to avoid mechanical damage to natural reefs from increased demand for diving. p. 217
Thoughts/reflections	2: Provides information on the attributes that affect choice of dive site, but the limit of the study to divers as the stakeholder group reduces its utility for our purposes

Ref ID# 6	Ramos et al 2007
Document type	Empirical research, Peer Reviewed Journal Article
Title	Stakeholder perceptions regarding the environmental and socio-economic impacts of the Algarve artificial reefs
Summary	To evaluate the overall perception of the effects of deployment of artificial reefs, a survey of stakeholders' opinions was undertaken based on a set of questions addressing various dimensions (environmental, social, and economic). The results obtained reflect the most important issues be impacted and the possibility of using them as indicators of relative

	success or failure – on the basis tht managers want to know which impacts are acceptable and which are not.
Geographic region	Algarve, Portugal
Structure Type	Artificial reef
Stakeholders / sectors	Commercial fishermen associations, anglers associations and clubs, diving schools and clubs, fisheries and environ- mental administrators, natural and social scientists, and local council representatives in the fisheries and environmental sectors
Social values explored	Perceptions of impact across social, economic and environmental elements of the AR - not social values
Methods:	What approach was adopted to engage stakeholders
	The questionnaires were sent directly to each representative by hand or via post mail, and were addressed to the highest representative of each body/institution, or to the person used to work with fisheries or environmental issues
	What approach was adopted to identify and evaluate social values
	Survey covered 44 key-stakeholder representatives distributed in six groups outlined above. The opinions of stakeholders were measured using summated rating scales. First, three dimensions expected to be impacted by reef deployment were selected: environmental (Deployment use area, ecological impact and bio-diversity, pollution, fishery and management), social (Demography and employment, Enforcement and communication, Opinion; Conflicts), and economic (production, costs to society, changes in local economic, safety at sea). For each dimension, an item-pool was constructed which included all the perceived predefined impacts (shown in brackets). The item-pool consisted of 54 ambiguous-free relevant items to be included in the survey of respondents' opinions. Key-stakeholders used 5-point Likert scales to state their positions about impacts. Used AMOEBA plots to view results.
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	In general different stakeholder-types take somewhat different positions and attitudes towards AR impacts: usually scientists are the most optimistic, whereas fishermen take the most sceptic view. Note: info below is 'perceptions' of impact not social values. Despite the differences found between those stakeholders who knew the reefs from first-hand experience and those that had only heard about them, the entire panel thought that the most important positive impacts belonged to the environmental dimension. Only fishermen and anglers were not sure about the environmental overall impact of the ARs. By contrast, divers and scientists were the most optimistic. Anglers, divers, and administrators considered that economic impacts over- shadowed social impacts, whereas scientists and others claimed the opposite. Factor-set analysis: the economic dimension seemed to have factor-sets perceived sceptically in terms of some factors (for example 'costs to society' and 'safety at sea') but more favourably in terms of others (e.g. 'production and benefits').
Other findings	Issues
	The worst impact perceived is the lack of enforcement measures to keep sea use rules in the deployment area. Other negative impacts relate to the uncontrolled augmentation of fishing pressure on the reefs, associated espe- cially with the activities of non-local boats having more powerful fishing capacity. Other perceived adverse impacts include the belief that ARs cause a loss of fishing gear which in turn entails additional costs in their replacement.
Other findings	Opportunities

	Structures: scientific evidence shows that there has been an increase in abundance of economically-important fish species on the pilot ARs surveyed since their deployment in the early 1990s On the positive side, the overall perception is that: ARs promote a specific habitat enriched with several different species, promoting bio-diversity; being also able to aggregate marine fauna, and the structures are more likely to attract local fishermen than other users. The use of local fishing vessels at the reef area was considered an environmental positive impact once it is recognised as a more sustainable way of fishing, when compared with larger vessels.
Thoughts/reflections	3. While useful in that the paper covers and compares a range of stakeholders, the focus is on perceptions of impact, not the 'values' of the stakeholders. Although these can in part be inferred based on the perceptions given.

Ref [1]	Saengsupavanich 2019
Document type	Empirical research, Peer-reviewed journal articles
Title	**Willingness to restore jetty-created erosion at a famous tourism beach**
Summary	This research revealed the intangible benefit of preserving the downdrift eroded shoreline at Cha-Am beach, Thailand. It integrated coastal engineering and environmental economics to urge for the beach restoration. Although providing some benefits, the jetty at Cha-am beach has also created severe downdrift coastal erosion. Future coastline change was predicted. The updrift part of the beach would be widened by approximately 8 m/yr, while the downdrift side of the jetty would experience severe coastal erosion by as much as 13 m/yr. A valuation of the downdrift eroded shore was consequently undertaken using a willingness-to-pay (WTP) study. Four hundred sets of questionnaires were surveyed using 10 different bid amounts. The huge non-market value of the downdrift beach might urge decision makers to initiate certain continuous beach restoration measures.
Geographic region	Cha-am beach, Thailand
Structure Type	Jetty
Stakeholders	Interviewed respondents were tourists on the beach, business operators of resorts and restaurants, and their employees at the updrift side. The people at the updrift area gained benefits from the sediment deposition so they had a sense of paying to restore the downdrift beach. Moreover, there were very few people along the downdrift area since the downdrift beach was very narrow, thus no tourism activity existed
Thoughts/reflections	0: Removed, only explores willingness to pay – no exploration of other social values. Relevant for Johanna.

	Sayer and Wilding 2002
Document type	Report on Activities, Peer reviewed journal article
Title	**Planning, licensing, and stakeholder consultation in an artificial reef development: the Loch Linnhe reef, a case study**
Summary	Discusses the licencing process for the Loch Linnhe Artificial Reef, which was one of the first applications successful under new guidelines under the auspices of the Oslo Paris Commission. Argues that the process was assisted by open dialogue with a range of user groups and local bodies.
Geographic region	European Union
Structure Type	Artificial Reef
Stakeholders / sectors	Licensing/regulatory bodies and fishermen, sport diving and fishing charter boat operators, recreational sailing groups, academia, and other identified experts, the media, and a wide range of governmental and non-governmental bodies such as local,

	community and regional councils, maritime heritage groups, and nature conservation bodies.
Social values explored	No specific values, focus was on the potential issues/concerns of different stakeholder groups so that these could be addressed in the application for AR development.
Methods:	What approach was adopted to engage stakeholders
	Interviews with fishermen, public meetings for general public. Local media channels were used constructively to assure a balanced representation of facts. In this case, a series of press statements was issued to local newspapers and radio stations. To share involvement with stakeholder groups, the establishment of the management committees turned out to be advantageous. Because the various groups may not share a common approach, they chose to have their meetings coordinated by independent facilitators
	What approach was adopted to identify and evaluate social values
	None, focus on priority issues rather than values. Outcomes of initial discussions with fishermen captured below.
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Responses to reef development differed based on the type of fishing gear employed. Static-gear fishermen expressed the concern that any new reef-based fishery would attract additional fishing effort into the area and that some of this effort would be directed at the existing wild stocks. The towed-gear sector expressed concerns regarding the concept of artificial reefs being used to protect areas of seabed through effort exclusion and, in particular, was concerned that the chosen site would not interfere with their existing fishing grounds The main concern raised during public meetings for the Loch Linnhe reef was that of the potential for ash- derived trace metals to leach from the blocks into the environment.
Other findings	Issues
Other findings	Opportunities
	Artificial reefs facilitate the restoration, manipulation, or protection of habitat availability and potentially assist in sustaining or restoring inshore fishery resources
Thoughts/reflections	1: Has some information relating to stakeholder engagement and the importance of involving stakeholders in the planning process. But does not explicitly try to understand stakeholder values, or how these vary across groups.

	Schaffer and Lawley 2011
Document type	Empirical research, Peer reviewed journal article
Title	An analysis of the networks evolving from an artificial reef development
Summary	Understanding the flow and development of knowledge within tourism networks is important to the success and value of the network, especially networks based on a single resource such as an artificial reef. Using the ex-HMAS Brisbane Conservation Park as the context, a network analysis was conducted with stakeholders to address the question: ‘How can network analysis be used to measure the social value of an artificial reef?’ The results of this study identified information flows over time, who was involved and not involved at different stages of development, as well as opportunities for further collaborative relationships.
Geographic region	Sunshine Coast, Australia
Structure Type	Artificial reef
Stakeholders / sectors	Tourism sector; business groups, community groups and government departments.
Social values explored	None
Methods:	What approach was adopted to engage stakeholders

	Interviews and snowballing for additional participants. To assess information flow, data collection focused on those individuals and organizations with a direct connection to the Conservation Park. Purposive sampling, using secondary sources, identified seven stakeholders from two groups: authorized dive operators and government departments. Stakeholders were interviewed using a semi-structured survey which requested respondents to identify additional stakeholders.
	What approach was adopted to identify and evaluate social values
	None – social values were not examined
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	The values of stakeholders were not explored
Other findings	Issues
	Network structure: A key management challenge when developing artificial reefs is stakeholder collaboration to generate knowledge and innovation for improved project outcomes. The whole network consisted of 492 ties (the connections that link stakeholders) of which 117 were transfer (one-way) ties and 375 exchange (two-way) ties. The greater number of exchange ties is critical for opening pathways for creating knowledge, innovation and sustainability Despite the main goal for the artificial reef being the enhancement of regional dive tourism (SQDERM, 2011), the Conservation Park network was weak in the areas of regional tourism organisations and hospitality support services. Respondents said contact with these stakeholders was limited and they were considered unimportant in the network. To address this gap, key stakeholders could broke ties with these groups to expand their involvement in the network
Other findings	Opportunities
	In summary, information was extensively sourced and knowledge was created at all stages of the project. This research can be used to facilitate consultation with stakeholders to investigate ways to collaborate, introduce new stakeholders and to work towards re-assessing goals and objectives as the tourism resource (Conservation Park) matures.
Thoughts/reflections	1: Paper only examines network linkages relating to the Conservation Park, does not examine the values or priorities of the different stakeholders within the network.

Ref ID #9	Schrouder and Love 2004
Document type	Review, Peer-reviewed journal article
Title	Ecological and political issues surrounding decommissioning of offshore oil facilities in the Southern California Bight
Summary	This paper summarizes and clarifies some of the issues and options that the federal government and the state of California face in decommissioning offshore oil and gas production platforms, particularly as these relate to platform ecology. Compared to the relatively supportive political climate in the Gulf of Mexico for ''rigs-to-reefs'' programs, conflicting social values among stakeholders in Southern California increases the need for understanding ecological impacts of various decommissioning alternatives (which range from total removal to allowing some or all of platform structure to remain in the ocean).
Geographic region	California, USA
Structure Type	Offshore oil facilities
Stakeholders / sectors	Not stated
Social values explored	None – although states 'Defining the social and ecological goals of decommissioned platforms as artificial reefs will be critical in evaluating the efficacy of any potential rigs-to-reefs program and the current and future performance of any artificial reef', p. 29

Methods:	What approach was adopted to engage stakeholders
	None
	What approach was adopted to identify and evaluate social values
	Literature review
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	The authors sort the multitude of stakeholder viewpoints regarding a rigs-to-reefs program into three groups, each of which is primarily defined by one social concern: 1. Community membership, consists of stakeholders who are concerned about community membership, and either oppose or support local presence of the oil industry. 2. Resource accessibility, stakeholders are primarily concerned with resource accessibility. A heterogeneous group, these citizens will either favour or oppose decommissioning alternatives depending on how these alternatives aid or inhibit their ability to access a particular resource (e.g. fishermen) 3. Environmental (marine life) issues: members of this group make decisions regarding decommissioning based on their perception of how certain marine populations or environmental ideals fare under the various decommissioning alternatives Of course, an individual may be influenced by more than one social value, and others may use arguments from multiple categories to promote a desired decommissioning outcome. The authors argue that stakeholders preferences for 'data' input into the decision making process is a function of their inherent support or lack of for the decommissioning process. They provide examples of how different stakeholders may value different scientific information based on how it contributes to their underlying values/ priorities. (see p 32 for example)
Other findings	Issues
	When there is greater scientific uncertainty, social values and political or economic factors often become more important in the decision-making process. Determination and ranking of ecological goals necessarily reflects cultural values. Thus, even if large amounts of ecological data regarding decommissioning consequences were available, controversies surrounding platform decommissioning will still arise because there is no formal ranking of which species or habitats have management priority. Further, there is no agreement on the space and time scales in which ecological impacts should be measured. Fishing greatly affects the ecological outcome of decommissioning alternatives. Therefore, managers should explicitly state whether reefing alternatives will be designated as marine protected areas
Other findings	Opportunities
	Economic incentives interact and overlap with social values. Additional financial resources may be used to develop or enhance projects important to stakeholders, and may be a sufficient incentive to alter the preferred decommissioning option for some groups. Finally, social values will also be important in directing how potential cost savings will be used. The overarching conclusion from both ecological and political perspectives is that decommissioning decisions should be made on a case-by-case basis.
Thoughts/reflections	3: One of the few articles that highlights stakeholder perceptions/values and how they relate to their support or not of decommissioning. However, results are only based on literature review, it is not an empirical research article. Has a nice figure showing the different alternatives for decommissioning oil and gas production platforms (p. 25)

	Schuett et al 2016
Document type	Empirical research. Peer-reviewed journal article
Title	Examining the Behavior, Management Preferences, and Sociodemographics of Artificial Reef Users in the Gulf of Mexico Offshore from Texas
Summary	This study used a mixed-mode approach (mail and online) to survey licensed private boat owners (26 ft [8 m] and larger) from Texas on the use, choice and management of artificial reefs in the Gulf of Mexico (GOM) offshore from Texas.
Geographic region	Gulf of Mexico, Texas
Structure Type	Artificial reef
Stakeholders / sectors	Boat owners (8m or larger)
Social values explored	None, focus on factors driving visitation to ARs
Methods:	What approach was adopted to engage stakeholders
	A total of 7,000 names and addresses were randomly selected from the population of registered boaters in the Texas Parks and Wildlife Department's database. Survey questionnaire sent to boat owners.
	What approach was adopted to identify and evaluate social values
	The questionnaire included behavioral queries, e.g., number of trips to the GOM, type of reefs visited, preferred distance to reef sites, and socio-demographics. Subjects were asked to rate the importance of various factors they take into account when selecting artificial reef structures for recreation. Also investigated participants' opinions regarding artificial reef management. 1,671 returned surveys.
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Factors defining which AR structure will be used for recreation: presence of fish (extremely important for over half of the respondents), followed by distance from port, depth of water, and diversity of marine life. For those with more trip experience, the importance of depth of water and presence of desired fish species increased. As the experience of boat owners increased, the location of artificial reefs in deeper water and the ability to see desired fish species became more important to boaters Thus, respondents with more experience wanted more artificial reefs in the GOM that are designed for specific uses and marked or identified, and believe they should be allowed to place them offshore as long as they are in safe locations.
Other findings	Issues
	Makes some reference to potential for overuse of sites if not managed effectively.
Other findings	Opportunities
	The main purpose of their trips to the GOM was to go fishing (83%), followed by boating (10%) and snorkelling or diving (6%). The most frequented structures visited were standing rigs and oil production structures, followed by toppled submerged rigs and oil production structures, and Liberty ships (U.S. cargo ships from World War II) and other submerged vessels
Thoughts/reflections	1: Only covers boat owners and explores reasons for visitation of AR.

	Seaman et al 2011
Document type	Book chapter, included as also identified via snowballing
Title	Artificial reefs as unifying and energizing factors in future research and management of fisheries and ecosystems

Summary	Uses case studies to explore the contribution of artificial reefs to meeting different biodiversity management goals.
Geographic region	Multiple cases
Structure Type	Artificial reef
Stakeholders / sectors	Focus on fishing sector across each case study
Social values explored	None, biological focus only
Thoughts/reflections	0: Remove from review, book chapter that focuses on biodiversity outcomes with no incorporation of stakeholder values.

Ref ID# 18	Sahni et al 2011
Document type	Empirical Research, Peer-reviewed journal article
Title	Artificial Reefs and Mass Marine Ecotourism
Summary	Deploying artificial reefs on the seabed has become popular in diving management. This practice has been advocated as a means towards meeting both ecological concerns and recreational divers' demands for diversification and themed experiences. Nevertheless, the perceptions of the user community itself – the scuba divers – regarding the establishment of artificial reefs have received only limited attention in the literature. Their views on critical issues concerning artificial reefs remain, as a result, fairly vague and speculative. The aim of the current paper is to bridge this gap in the literature by presenting the results of a study exploring divers' attitudes and preferences with regards to the plan for a new artificial reef along the northern shore of the Red Sea in Eilat, Israel.
Geographic region	Red Sea in Eilat, Israel
Structure Type	Artificial reef
Stakeholders / sectors	Diving
Social values explored	Preferences for different AR forms, views on ecological benefits of ARs, diving motivations.
Methods:	What approach was adopted to engage stakeholders
	Six trained research assistants recruited the participants in nine different diving clubs
	What approach was adopted to identify and evaluate social values
	Survey. First, a list of prominent diving sites in Eilat was presented to the participants, who were asked to indicate the degree to which they prefer to dive at each site. The list includes both NRs (e.g. Japanese Gardens, Dekel Beach and Aqua Sport), and ARs (e.g. Satil, Yatush and Tamar Reef). The second part of the questionnaire measured preferences for potential forms/structures of the future AR to be positioned along the northern shore. Respondents were asked other relevant questions for planning and deploying ARs, such as their favoured depth and location for placing the AR, and what would be the implications of such a new AR on the frequency of their diving in this area. Participants also expressed their views with regards to the environmental impacts of an AR, its contribution to the diving experience and their general level of support for placing a new AR along the northern shore of the Israeli coast. The last section of the survey included references to the participants' socio- demographics and diving-related characteristics, including motivations for diving.
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Most favoured AR structures by far were large naval ships and airplanes, followed by culverts. Other popular structures were small boats and barges, and replicas of coral reefs. The least favoured structures include tyres, concrete blocks, pipes, walls and cars or car parts.

	Slightly more than three-quarters (78.6%) of the respondents expressed the belief that a new AR would contribute to the natural marine environment. A higher percentage (more than 90%) stated that the AR would contribute to the diving experience, yet less than that (70.3%) indicated that they would be diving more frequently. There is a clear tendency towards preferring large objects as ARs, rather than small objects. One of the most popular diving sites was the Satil, which is a 45 m long missile boat, while smaller AR's (Yatush and Tamar Reef) received quite neutral scores. The respondents appear to favour structures that have a clear theme, rather than abstract forms. Experienced, highly trained divers were significantly more in favour of the deployment of ARs than less trained divers. Participants' declared motivations to dive include, 'relaxation' and 'special underwater feature', followed by 'expanding knowledge'
Other findings	Issues
Other findings	Opportunities
	To alleviate the pressure from the coral reefs and to increase the carrying capacity of the sites, ARs are being deployed world-wide to serve as underwater attractions (or theme parks) that can divert the lion share of divers from the more sensitive areas.
Thoughts/reflections	2: Provides some insight into diving sectors preferences in relation to AR.

	Simard et al 2016
Document type	Empirical Research, Peer reviewed journal article.
Title	Quantification of Boat Visitation Rates at Artificial and Natural Reefs in the Eastern Gulf of Mexico Using Acoustic Recorders
Summary	Artificial reefs are commonly used as a management tool, in part to provide ecosystem ser- vices, including opportunities for recreational fishing and diving. Quantifying the use of artifi- cial reefs by recreational boaters is essential for determining their value as ecosystem services. In this study, four artificial–natural reef pairs in the eastern Gulf of Mexico (off western Florida) were investigated for boat visitation rates using autonomous acoustic recorders. Digital SpectroGram (DSG) recorders were used to collect sound files from April 2013 to March 2015.
Geographic region	Gulf of Mexico
Structure Type	Artificial Reef
Stakeholders / sectors	NA
Other Findings	In every artificial–natural reef pair studied, significantly more boats visited the artificial reef site than the natural reef site. At the inshore locations, visitation rates at the artificial reef sites were approximately ten times higher than those at natural reefs. Differences in visitation rates were approximately eight times higher at the offshore artificial reef Pinellas II than the natural reef Caves The high rates of boat visitation at artificial reefs in comparison to natural reefs in this study are likely due to increased recreational value perceived by sport fishers. Recreational fishermen often report high success rates on artificial reefs [23,27], and the opinion that artificial reefs increase the amount of desirable species is shared by most users in Florida [24].
Social values explored	None – explores boat visitation rates only

Thoughts/reflections	0: No assessment of social values, externally (via digital records) examines boat visitation rates. Makes statements regarding the drivers of visitation to ARs, but these are not empirically tested (see 'other findings' above for example).

	Stolk et al 2005
Document type	Empirical research, Peer-reviewed journal article.
Title	Perceptions of Artificial Reefs as Scuba Diving Resources: A Study of Australian Recreational Scuba Divers
Summary	Marine-based recreation and tourism activities have experienced substantial growth over the past few decades and concerns about the ecological sustainability of many of these activities have been recognised by researchers, policy-makers and the recreation and tourism industries. One strategy to deal with diver-induced impacts is the creation of new or artificial reefs which, when established, can become substitute dive sites for more naturally occurring reefs. However, there have been very few studies into the acceptability of these substitute reef environments to divers and the social aspects of diving on artificial reefs. This paper explores the perceptions of diving on artificial reefs through a questionnaire survey of a sample of 337 Australian scuba divers.
Geographic region	Australia
Structure Type	Artificial reef
Stakeholders / sectors	Divers
Social values explored	None
Methods:	What approach was adopted to engage stakeholders
	Using a questionnaire, a sample of Australian recreational scuba divers was surveyed during the period August 2004 to June 2005. Participants were recruited by actively publicising information about the study, via print, radio and television, dive club newsletters and noticeboards, electronic mail bulletins from community organisations, internet chat rooms, news stories on websites and word of mouth communication
	What approach was adopted to identify and evaluate social values
	None reported
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	None reported
Other findings	Issues
	Not stated
Other findings	Opportunities
	Research Needs: Understanding scuba divers' attitudes, perceptions and satisfaction levels with regard to artificial reef environments is important in order to adequately plan for future sustainable tourism and recreation. If properly planned, designed and managed, artificial reefs may augment the supply of marine resources available to diving enthusiasts without compromising their preferred type of experience.
Thoughts/reflections	1: Very strange paper, very detailed upfront (ie lit rationale and methods), then combines results and discussion and only discusses diver demographics and participation frequency, with not other results presented or discussed and no conclusion. Therefore, provide no contribution to our study. Has a small section on Busselton jetty, which might be useful if this becomes a case study (see p. 158)

Ref ID# 24	Voyer et al 2017

Document type	Empirical Research, Peer-reviewed journal article
Title	**Connections or conflict? A social and economic analysis of the interconnections between the professional fishing industry, recreational fishing and marine tourism in coastal communities in NSW, Australia**
Summary	Resource conflict is a common feature of coastal management. This research examined the relationships between the three sectors (professional fishing, recreational fishing and broader coastal tourism) using economic valuations, qualitative interviews and a large-scale representative questionnaire of the general public. The results revealed highly interconnected and mutually supportive relationships, with professional fishing providing a range of services that benefit both tourism and recreational fishing. These results suggest that spatial management exercises that seek to segregate or remove one sector from an area, may be counter- productive to the interests of all these groups.
Geographic region	Australia, NSW
Structure Type	None – focus is on the fishing industry in general
Stakeholders / sectors	Professional fishing, recreational fishing and broader coastal tourism.
Social values explored	Relational dimensions of wellbeing – i.e. the interactions and relationships that help determine whether citizens are able to achieve what they value in life
Methods:	What approach was adopted to engage stakeholders
	Interviews with fishermen: Initial contact with interview participants was made in a variety of ways, including purposive sampling of industry bodies, cooperatives and community groups, opportunistic sampling (e.g. via advertising 'drop in sessions' through local media or industry channels) and 'snowball' sampling whereby people interviewed recommended additional people to contact. General public: A total of 1423 interviews were completed via computer assisted telephone interview (CATI). Survey focused on coastal residents Fish merchants and cooperatives: 77 interviews were completed via CATI. The sample was obtained partly from pre- existing contacts, especially the fishing cooperatives, and partly from a random selection from public phone records Tourism and hospitality providers: An online questionnaire of the tourism and hospitality industry. The survey was distributed through a range of channels including regional and local tourism bodies and industry groups in coastal NSW.
	What approach was adopted to identify and evaluate social values
	Focus: Detailed examination of how professional fishing interacts with recreational fishing and tourism sectors in coastal communities. The fieldwork commenced with a series of qualitative interviews (160) which identified features of these relationships that warranted closer examination. Further quantitative data was collected based on these key themes using economic and social questionnaires. Interviews were audio recorded and transcribed in full. All the transcripts and interview notes were entered into NVivo 10 and coded to identify key themes
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Social and economic interactions between the different user groups were examined, ie between professional and recreational fishing; followed by between professional fishing and tourism sectors. Found that social and economic interactions were generally positive, and uses the fidnings as a basis for rejecting management approaches that focus on segregation or removal of certain groups. Some of the interrelationships identified include: (i) professional and recreational fishing: recreational and professional fishing sectors supported each other economically and socially through the bait industry. 35% of respondents identified as recreational fishers. Of them, 78% agreed or strongly agreeing that they preferred local bait, even if it is more expensive. This support is primarily driven by a desire to support the local community (90% agree); (ii) professional fishing and

	tourism: contribution of the industry to tourism through the provision of sought-after seafood meals for visiting tourists and via the provision of an experience for visitors wishing to witness fishing practices or a working harbour.
Other findings	Issues
	Conventional valuation approaches to fisheries were conducted as part of this project and they found that a direct comparison of the economic values of professional fishing with the other two competing sectors would likely result in a decision to favour the prioritisation of recreational fishing and tourism. Comparisons of this nature have been used in the past to justify calls to restrict professional fishing in Australia. The broader analysis, however, highlights the dangers inherent in such a narrow assessment of the value of a particular industry.
Other findings	Opportunities
	Value of Social Assessment: Relying on economic valuations of each sector as if they stand alone is insufficient to adequately understand their roles in local communities. Resource allocation decisions should be based on evaluations that consider the interconnections between sectors, and consider whether negotiated sharing of resources may provide greater community benefits than excluding certain groups of users.
Thoughts/reflections	2. Good paper with a specific focus on social interactions and benefits of three sectors, but no focus on offshore marine infrastructure. Argues that looking beyond purely economic measures to consider contributions in context with a range of other factors – specifically how the industry supports and interacts with other important sectors in regional economies, and the extent to which local communities value those contributions, is a very valuable process that provides a greater understanding of the management issues/goals.

	Klaoudatos et al 2012
Document type	Journal Article – Discussion paper
Title	The greek experience of artificial reef construction and management.
Summary	This paper discusses the importance of having clear management protocol for artificial reefs and how this can benefit the environment as well as social and economic factors.
Geographic region	Greece
Structure Type	Artificial Reefs
Stakeholders / sectors	N/A
Social values explored	Acceptance of artificial reefs from stakeholders
Methods:	What approach was adopted to engage stakeholders
	N/A
	What approach was adopted to identify and evaluate social values
	N/A
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	No findings as no research process appears to be engaged in
Other findings	Issues
	If the community opposes the development of an artificial reef they will not engage in research and preliminary development
Other findings	Opportunities
	Artificial reefs can increase employment and further expand infrastructure – theme park, tourist shops, hotels, restaurants Success of artificial reef is dependent on the support of the community – willingness to help with research and preliminary development

Thoughts/reflections	1: though it does mention some social impacts that artificial reefs can have a lot of them are not backed up with references. Launches straight from aims to a discussion. References that would be available for snowballing are only in Greek. No stakeholder consultation and heavy management focus.

Ref ID# 25	Stolk, Markwell, & Jenkins, 2007
Document type	Peer Review Journal Article
Title	Artificial reefs as recreational scuba diving resources: A critical review of research.
Summary	This paper systematically reviews literature relating to scuba divers recreational use of artificial reefs, examines papers for salient themes and presents a conceptual model of artificial reef dive experience. Key salient themes found in literature were: social dimensions, socioeconomic impact and environmental engineering. The proposed conceptual model described diver experience from the domains of influential factors, significant outcomes and the relationship. Article also provides a definition of artificial reefs.
Geographic region	No specific region – literature review of ARs around the worlds: USA, Japan, Europe, Taiwan, Australia, South Africa and New Zealand
Structure Type	Artificial Reefs
Stakeholders / sectors	Recreational scuba divers
Social values explored	Artificial reefs as marine tourism and recreational resources Recreational divers structure preferences Recreational divers user type preferences
Methods:	What approach was adopted to engage stakeholders
	No stakeholder engagement – literature review
	What approach was adopted to identify and evaluate social values
	Review 6 papers found that specifically explore scuba divers recreational use of artificial reefs from the lens of social dimensions, socioeconomic impact and environmental engineering
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Social dimensions Recreational divers have preferences for artificial reefs based on factors, including: the reef's structure, size, location, depth, resident species and surrounding sea conditions Exclusion of recreational user groups from artificial reefs may improve recreational scuba diver experience Socioeconomic dimensions Consumptive and non-consumptive recreational divers cannot operate on the same artificial reefs structure sustainably. No-take zones need to be established to provide protection for artificial reef sustainability Environmental engineering dimensions Creation of specifically engineered recreational diving areas of differing complexity is seen as a way of maximise diver enjoyment
Other findings	Issues
	Divers attitudes must be understood to plan for sustainable tourism
Other findings	Opportunities
	promoting ecotourism-related activity around these artificial reefs may: Redistribute tourist activity away from at-risk locations Increase tourist access to environmental areas easier access for most potential visitors than ecotourism in pristine natural areas;

	Provide the opportunity for more socioeconomic research
Thoughts/reflections	2: provide definition of artificial reefs which may be useful in future. No direct stakeholder engagement but explores social values found in other studies. Good for snowballing. As only 6 articles were reviewed would probably be better of reading those articles to see if they are relevant.

	Strickland-Munro et al 2015
Document type	Technical Report
Title	**Values and aspirations for coastal waters of the Kimberley: social values and participatory mapping using interviews**
Summary	This report aimed to explore social values and aspirations towards coastline and marine environment of stakeholders in the Kimberly (Perth and Darwin) over a 3 year period. This was achieved by conducting mapping exercise and semi-structured interviews. Man-made aquatic infrastructure is not specifically explored however, social values are explored in-depth. Paper discusses major themes found within 4 key use areas direct use, consumptive, direct use non-consumptive, indirect use and non-use values.
Geographic region	Kimberly Region, Western Australia
Structure Type	N/A broad coastal and marine region
Stakeholders / sectors	Aboriginal traditional owners Aboriginal and non-Aboriginal residents Tourists and the tourism industry Commercial and recreational fishing Aquaculture Federal, state and local government Mining, oil, gas and tidal energy interests Marine transport and aviation Environmental and non- government organisations
Social values explored	**Direct use, non-consumptive values** Physical landscape Aboriginal culture Therapeutic Recreation–other Social interaction and memories Experiential Learning and research Historical Spiritual **Direct use, consumptive values** Recreation–camping Recreation–fishing Subsistence Economic–tourism Economic–commercial fishing, pearling and aquaculture **Indirect use values** Biodiversity **Non-use values** Bequest

	Existence
Methods:	What approach was adopted to engage stakeholders
	Data collection relied on face-to-face, semi-structured interviews consisting of 8-10 open- ended questions Questions were based on literature exploration and had a focus on eliciting values related to the Kimberly area Participants were also asked to mark areas on a map of the Kimberly region of areas the saw value in
	What approach was adopted to identify and evaluate social values
	Interviews: analysed using grounded theory an inductive technique generating themes from constant comparison of patterns and emerging concepts. Emergent concepts were then organised according to the values typology: (1) direct use, non-consumptive values; (2) direct use, consumptive values; (3) indirect use values; and (4) non-use values Maps: spatial analysis was conducted to see commonalities in areas of value and place numerical values on these areas
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Below the key themes are listed along as categorised by the types of use and % of how often they were discussed in interviews Direct use, non-consumptive values Physical landscape (77%): aesthetics, tidal phenomenon, coastal geology, unique nature experiences, the Kimberley's 'pristine untouched environment' Aboriginal culture (63%): cultural sites, connection to country, evidence of historical use, and transmission of cultural knowledge Therapeutic (62%): make people feel mentally better, calm, or recharged. Major elements: escapism, relaxation, remoteness, and personal recharge Recreation–other (62%): exploration of environment Social interaction and memories (56%): social experience and home/ childhood memories Experiential (51%): adventure, iconic destination, blown away experience, private experience Learning and research (34%): Typically expressed in terms of scientific research, but also monitoring, exploration, discovery and more generally the ability to learn about the environment Historical (19%): European and missionary history Spiritual (11%): nature as a spiritual landscape Direct use, consumptive values Recreation–camping (58%): places that offer recreational activities centred on overnight or longer stays in transient and/or fixed accommodation in coastal areas Recreation–fishing (54%): places that offer recreational activities relating to the catching of fish species as well as gathering of other marine life Subsistence: subsistence food collection and fresh water provision Economic–tourism (44%): Generic tourism values, or more specifically refers to eco or nature based tourism, or Aboriginal cultural tourism. Economic–commercial fishing, pearling and aquaculture (24%): Values derived from commercial fishing, aquaculture and pearling activities Indirect use values Biodiversity (80%): marine fauna, reef biodiversity, migratory shorebirds and mangroves Non-use values

	Bequest (7%): places that offer future generations the ability to know and experience places, landscapes and habitats as they are no Existence (4%): knowing that a particular place, environmental resource and/or organism exists, regardless of having physically been to or directly used an are
Other findings	Issues
Other findings	Opportunities
	Implications for future management as the area is highly valued by both aboriginal and non-aboriginal stakeholders – they should be involved in the decision making process Must consider social impacts always when planning for development
Thoughts/reflections	1: though man-made aquatic infrastructure is not explored specifically the study focuses heavily on social values within the Kimberly region. As such, that report may be useful for providing baseline insights into how stakeholder groups feel about the environment. Also gives insights into types of research that have already been conducted around this area. May be useful for comparison with future data that is collected. Flag for use for causal model.

Ref	Taylor et al 2017
Document type	Peer Reviewed Journal Article
Title	**Fisheries enhancement and restoration in a changing world.**
Summary	This paper discusses the importance of maintaining fisheries and how they can provide an environment where things like aquaculture technology, quantitative modelling, social science, physiology and ecology can interact. These interactions can be used to estimate enhancement potential, improve enhancement strategies, assess enhancement outcomes, and support adaptive management.
Thoughts/reflections	0: upon reading there were 2 papers discussed within this paper that seemed within scope. One paper was already found using databases and the other was added to snowballing. Beyond that this paper does not seem like it would add value as there is no in depth stakeholder engagement or social value focus. Removed from review.

	Tessier, et al 2015
Document type	Peer Reviewed Journal Article
Title	**Assessment of French artificial reefs: due to limitations of research, trends may be misleading**
Summary	This report explored research trends relating to artificial reefs in France from the 90s onwards. Areas explored included fish populations, reef design, ecology richness, and stakeholder perceptions towards artificial reefs. Overall findings suggest that more long term research should be conducted within the areas of trophic dynamics, ecological connectivity of habitats, and socioeconomics.
Geographic region	France
Structure Type	Artificial reefs
Stakeholders / sectors	Not specifically stated: Commercial/recreational fishermen Recreational divers Recreational fishermen
Social values explored	Effectiveness to maintain artisanal fishing How social value is explored on ARs Management implications
Methods:	What approach was adopted to engage stakeholders

	N/A Literature review of 45 articles relating to France and artificial reefs from the 90s onwards
	What approach was adopted to identify and evaluate social values
	N/A review of the literature
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	no socioeconomic research concerning impact, cost- benefit and cost-effectiveness analyses has been conducted for ARs in France Fishermen concern with AR deployment is if they will catch more after deployment Experimental fishing is the most common sampling technique used to test if fishing yield increased after AR deployment Majority of fishers new that the ARs existed but not know the exact location Currently, user views of ARs are becoming broader. ARs are perceived as multiuse Perceptions of ARs have implications on future management
Other findings	Issues
	Socioeconomic research in combination has not been conducted yet Few studies researching non-professional use of ARs and social value
Other findings	Opportunities
	Funding for artificial reefs in France has increased All potential stakeholders should be considered in social value of AR research
Thoughts/reflections	1: study mentions social values but has very limited discussion on social value – this may reflect the limited availability of social value research on artificial reefs in France. Relevant papers have been pulled out for snowballing purposes however some were only in French.

	Ten Voorde et al 2009
Document type	Peer reviewed journal article
Title	Designing a preliminary multifunctional artificial reef to protect the Portuguese coast
Summary	Article focuses on optimising design of artificial reefs so that it can be used for multiple purposes. Tests of geometry of proposed reef are performed to assess suitability.
Thoughts/reflections	0: no social value focus. Design of artificial reef focus for multiple functions like surfing.

Ref ID #8	Ten Brink & Dalton 2018
Document type	Peer Reviewed Journal Article
Title	Des Perceptions of commercial and recreational fishers on the potential ecological impacts of the Block Island Wind Farm (US)
Summary	Researchers interview commercial and recreational fisher to understand their perceptions of how offshore windfarms has affected fishing behaviour and fish ecology before during and after construction. Themes are organised by behavioural and ecological impacts.
Geographic region	Rhode Island, USA
Structure Type	Block Island Wind Farms (BIWF)
Stakeholders / sectors	Recreational or Commercial Fishers

Social values explored	Past and current uses and perceptions of change before and after wind turbines were constructed and operational (ecological and behavioural impacts)
Methods:	**What approach was adopted to engage stakeholders**
	Purposive sampling to invite participants to engage in a semi-structured interview. tried to recruit fishers from across a diversity of commercial and recreational gear types and different home ports. Interviews focus on interviewees: • Fishing experience and use of the study area before the construction of the BIWF • Use of the area and any ecological changes in the area during construction of the BIWF • Perceptions of any changes in the area and uses of the area after the BIWF was constructed • How individual behaviors in the area changed as a result of the BIWF
	What approach was adopted to identify and evaluate social values
	Interviews coded in NVivo for common/emergent themes that were coded as either behavioural or ecological
Findings	**Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]**
	Increased recreational fishing in the area since the turbines were constructed – wind turbines may function as a landmark Wind turbines may provide ability to catch targeted species of fish Turbines viewed as an eyesore but others enjoyed the visual aesthetics Concerns over having to navigate around the infrastructure Recreational and commercial fishers not compensated for loss of access during construction Perceived loss of productive fishing ground Influx of recreational fishers causes loss of ground for commercial fishers (feelings of displacement) More commercial rod and reel fishers in the areas since building Positive reception for energy production of BIWF Concern about how or if the BIWF would be decommissioned in the future BIWF create new structure for fish – artificial reef though many felt that it had had no difference on the amount/species of fish Construction scared away fish
Other findings	**Issues**
	Infrastructure as an eyesore Loss – gear, fishing ground, money, fish available during construction
Other findings	**Opportunities**
	Building infrastructure has meant increased fishing activity in the area Provide habitat for fish
Thoughts/reflections	3: in depth examination of perceptions of two stakeholder groups before and after the construction of man-made aquatic infrastructure. Concept of asking for perceptions before AND after is interesting

	Kevin Leleu et al 2012 (From Tessier, et al 2015)
Document type	Peer Reviewed Journal Article
Title	**Fishers' perceptions as indicators of the performance of Marine Protected Areas (MPAs)**

Summary	This paper studies fishers perceptions of marine protected areas, in particular two no-take zones that exist within this area. No take-zones in this area ban fishing and harvesting, scuba diving and anchoring. Artificial reefs exist near but not in these areas to prevent trawling.
Geographic region	North Western Mediterranean, Parc Marin de la Coste Bleue, France
Structure Type	Marine protected area no-take zone with artificial reefs
Stakeholders / sectors	Isn't clear if recreational or commercial fishers
Social values explored	How NTZs affect artisanal fishery in general The balance between loss of fishing grounds and NTZ benefits Fishing interest near the NTZs The seniority of fishers (number of years they have been fishing within the MPA)
Methods:	What approach was adopted to engage stakeholders
	Fishing activity: estimate for the year and The choice of gear, the species targeted and the fishing grounds, asked to plot where they fish on maps Semi-structured interviews: to appraise their perception of the effects of the NTZs on their own activity, on the artisanal fishery in general and on the marine ecosystem, perceptions of loss of fishing ground and if they would use the ground if the no-take zone did not exist, and the most important factors guiding their fishing spot choice.
	What approach was adopted to identify and evaluate social values
	Qualitative answers were assessed quantitatively using frequency of answer
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	No negative perception of the effects of NTZs, with the exception of a slight impression that losses exceed Positive opinions towards no-take zones were most predominate Fishers had more negative or neutral perceptions about the no-take zones when evaluating how it impacted their own activity when compared to ow they evaluated broader activity other than their own such as the ecosystem or overall effects positive perceptions are inversely linked to seniority. Fishers with less seniority seem to be more attracted by the zone adjacent to the NTZs than those with more seniority – seniority in the number of years they have been fishing Minimal fishers expressed an interest in fishing more frequently near the NTZs, even when they regarded the NTZs as being beneficial The most important factors involved in the choice of a fishing location were fish abundance (44%), presence of suitable habitats (38%), harbor proximity (31%) and weather (13%)
Other findings	Issues
	Fishers are concerned with how NTZ impact their own activity more than the broader impacts it may have
Other findings	Opportunities
	High degrees of social acceptance of MPA and NTZs may be explained by good management and research that engages and informs the community
Thoughts/reflections	1: does not specifically assess man-made marine infrastructure. HOWEVER, explores social values and no-take zones which is something that may relate to infrastructure e.g. oil and gas platforms are no take zones, when developing artificial reefs a temporary no-take zone may have to be put in place.

	Garlock and Lorenzen 2017 (From Taylor et al 2017)
Document type	Peer Reviewed Journal Article
Title	Marine angler characteristics and attitudes toward stock enhancement in Florida
Summary	This study explores fishers perceptions towards ways of managing of managing fish populations. Attitudes explored focus on fishing using a quantitative survey that asks questions like ‘‘When I go fishing, I’m not satisfied unless I catch at least something’. Management tools include restricting size limits, stocking hatchery-reared fish, restoring habitats or providing artificial habitats.
Geographic region	Florida
Structure Type	Artificial structures/habitats
Stakeholders / sectors	Recreational Angler Fishers
Social values explored	Perceptions of methods for managing fish populations
Methods:	What approach was adopted to engage stakeholders
	Internet-based survey was used to collect information from anglers on their fishing behavior and experience, fishing preferences, motivations, demographics and attitudes toward fisheries management options including stock enhancement
	What approach was adopted to identify and evaluate social values
	Quantitative analysis of the Likert scale answers
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	60% of inshore anglers supported stock enhancement whereas support for providing artificial habitat and for protecting or restoring degraded habitat was considerably greater, 76% and 85% respectively
Other findings	Issues
Other findings	Opportunities
	Majority of responders agreed that some form of management for fish populations should be put in place
Thoughts/reflections	1: study has more of a focus on increasing fish populations and providing ways of doing that. Small focus on artificial reefs as an option of population numbers which is the only reason this paper should not be removed.

	Brock, 1994 (From Stolk, Markwell, & Jenkins, 2007)
Document type	Peer Reviewed Journal Article
Title	Beyond fisheries enhancement: Artificial reefs and ecotourism
Summary	This study explores how artificial reefs can be used to improve and increase fish populations and tourism in communities. Researchers evaluate these two areas using an economic lens. No social value.
Thoughts/reflections	0; no social value, observation more than stakeholder engagement. Removed from review.

Ref ID# 22	Ditton et al 2002 (From Stolk, Markwell, & Jenkins, 2007)
Document type	Peer Reviewed Journal Article
Title	Demographics, attitudes, and reef management practices of sport divers in offshore Texas waters

Summary	This study aimed to characterise the recreational diver activity in Texas offshore artificial reefs. Researchers wanted to examine and understand this stakeholder groups demographic characteristics, participation patterns, level of involvement in sport diving, diving motivations, attitudes, and management preferences.
Geographic region	Texas, USA
Structure Type	Artificial Reefs
Stakeholders / sectors	Recreational divers
Social values explored	Artificial reef structure preference Importance values of artificial reefs Attitude values towards artificial reefs
Methods:	What approach was adopted to engage stakeholders
	Stepwise approach: 1. Inventory of dive charter boat operators was completed in 1997 2. Dive boat operators to survey of their customers to select a random sample of their clientele 3. Data collected of recreational divers using a mail questionnaire: Questions assessed overall sport diving activity and experience, saltwater scuba diving activity in Texas and elsewhere, reefs, water depth preferences in the Gulf of Mexico, and motivations for the ‘‘last diving trip’’ to the Texas coast, and demographic information of the divers.
	What approach was adopted to identify and evaluate social values
	Quantitative analysis of survey
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Individuals who dived on ARs reported diving in both fresh and saltwater AR divers reported they participated in night-diving (81%), underwater photography (53%), wreck diving (52%), and marine identification (52%), and spear fishing (26%) The most preferred AR material was large naval ships (68.4%) with oil productions strucutures as second (17.7%) Importance statements More than 50% of the divers rated 12 out of 15 experience motivations for diving either as very or as extremely important reasons for sport diving on their last trip to the Texas coast: • Family recreation • Learn about environment Experience surroundings Look at fish • Outdoors • Relaxation • Experience adventure • Get away from demands Experience tranquillity • To be with friends • For the exercise • Develop skills and abilities • Get away from routine • New and different things Spearing fish to eat Attitude statements Most AR divers agreed with five of the nine attitude statements asked: • Mooring buoys should be provided at all artificial reef sites 80% • Certain artificial reefs should exclude spear-gun fishing’ 73% • more funds should be used to deploy large naval ships as reefs’ 72% • Certain reefs should be designated for specific uses such as for diving only or recreational fishing only 71% • All sub- merged artificial reefs should be identified with marking buoys 69% 82% disagreed that there were currently too many AR

Other findings	Issues
	Limited stakeholder engagement outside of "sports divers"
Other findings	Opportunities
	Future opportunity for more engagement with other stakeholder groups
Thoughts/reflections	2: good study for exploring a particular stakeholder group. Does not go in depth as to WHY they have these values/attitudes etc.

	Milon, 1989 (From Stolk, Markwell, & Jenkins, 2007)
Document type	Peer Reviewed Journal Article
Title	Artificial marine habitat characteristics and participation behavior by sport anglers and divers
Summary	Researchers used a mail survey to assess the use of reefs habitats available on Florida by recreational anglers and divers. Socioeconomic and demographic values are assessed using the survey. Different use values are placed on artificial reefs by the two stakeholder groups.
Geographic region	Florida
Structure Type	Artificial Reefs
Stakeholders / sectors	Recreational Anglers and Divers
Social values explored	Objective for using artificial reef
Methods:	What approach was adopted to engage stakeholders
	Mail surveys were sent out to private registered boat owners and assessed: Participation in fishing and diving activities for the prior 6 months. General descriptive information about boats and socioeconomic characteristics. Report specific details about most recent trip and type of environment visited: natural or artificial, time spent at specific sites, the size of the party, and the number and weight offish harvested Rate reasons for using artificial reefs
	What approach was adopted to identify and evaluate social values
	Binomial logit analysis and multinomial logit analysis
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Objective for use in order form highest rated to lowest: *Anglers* Better chance of harvesting fish Previous success at reef sites Easy to locate Proximity to shore Proximity to other boats Recommendations from others *Divers* Easy to locate Previous success at reef sites Proximity to shore Recommendations from others Better chance of harvesting fish

	Proximity to other boats
Other findings	Issues
	Users prefer sites that are in close proximity to their launch area
Other findings	Opportunities
	reef users were likely to be more avid anglers or divers who were better informed and better equipped to locate the reef sites – importance of prior knowledge
Thoughts/reflections	1: explores social values of two specific stakeholder groups but does not go in depth as to why and has limited responses by giving set reasons for use.

	Tompkins, Few, Brown, 2008 (From Kienker et al 2018)
Document type	Peer Reviewed Journal Article
Title	Scenario-based stakeholder engagement: incorporating stakeholders preferences into coastal planning for climate change
Summary	
Thoughts/reflections	0: looking at climate change and social value/stakeholder opinions rather than a focus on man-made aquatic infrastructure. Must be noted that they are using a decision support system and that this paper could be useful later on when justifying workshop techniques.

Ref ID #21	Evans et al 2017 (From Kienker et al 2018)
Document type	Peer Reviewed Journal Article
Title	Stakeholder priorities for multi-functional coastal defense developments and steps to effective implementation
Summary	This study employed a Delphi technique to extract informaiton from experts regarding planning priorities for coastal defence developments, potential second-hand benefits from costal defence development and their priorities, overall support for coastal defence development that have multiple functions, consensus of perceptions across stakeholder groups and steps/implementation moving forward. Costal defense developments can include sea walls, reinforcing already existing seasides/beachers, artificial reefs, concrete blocks etc. Once stakeholder perceptions were determined they were asked to rank them in order of perceived importance and preferred importance
Geographic region	England and Wales
Structure Type	Misc. multipurpose costal defense structures
Stakeholders / sectors	Academic non-specialist Academic Specialist Conservation Ecological Consultant Engineering Consultant Local Authority Statutory Bodies
Social values explored	Importance considerations values Potential secondary benefit values Reasons for multifunctionality Barriers to effective implementation
Methods:	What approach was adopted to engage stakeholders
	Initial survey: indicate level of support for traditional and then multi-functional coastal

	defense structures on a Likert scale. This was used to inform the Delphi survey Delphi survey: questions are asked over a number of rounds, and between each round, responses are analysed and fed back to the panel in an iterative process. 3 rounds 1 scoping and 2 convergence. • What are the most important considerations when planning coastal defense works (i.e. construction or maintenance of engineered coastal defense structures)? • What are the potential secondary benefits of engineered coastal defense structures (i.e. beyond their primary function of providing protection against flooding and erosion)? • Would you be more supportive of the construction of additional coastal defenses around the UK if they were multi-functional structures (i.e. ones that deliver secondary ecological and/or socio-economic benefits)? Why?
	What approach was adopted to identify and evaluate social values
	Quantitative analysis for preliminary survey (ANOVA) Qualitative analysis for Delphi approach with 3 rounds (1 scoping 2 convergence) then analysis of data for themes (Nvivo) after the scoping round. Convergence rounds individual ranks participants ranked themes that came out of initial round by importance. Box and whisker plots of median scores, interquartile ranges and outliers were plotted to visually assess the level of consensus among the panel.
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Perceived priority rankings (in order from most important to least) Essential criteria Cost Net socio-economic impacts on local communities and businesses Net ecological impacts Net landscape impacts Level of community support Net culture and heritage impacts Carbon footprint Opportunities for research and development Opportunities for education and outreach Preferred Priority ranking Essential criteria Net ecological impacts Net socio-economic impacts on local communities and businesses Cost Net landscape impacts Carbon footprint Opportunities for research and development Level of community support Net culture and heritage impacts Opportunities for education and outreach High consensus of ranking across stakeholder groups however views on cost varied greatly All agreed that essential criteria is the most important Education and opportunities for outreach was consistently the least important

	Secondary values (in order highest value to lowest) Habitat for natural rocky shore communities Habitat for species of conservation interest Refuge for exploited species Habitat heterogeneity in structure design Enhanced commercial fisheries Safeguarded biosecurity Enhanced amenity/recreation House other technologies Mariculture opportunities Reduced carbon footprint Opportunities for research and development – investigating marine/coastal ecology Enhanced landscape value Opportunities for education and outreach Enhanced culture and heritage value Potential for reasons for building-in secondary benefits (in order from highest to lowest) Positive ecological impacts Divert pressure from natural systems Positive socio-economic impacts on local communities and businesses Increase likelihood of scheme progression Reduce maintenance requirements Research and development Enhance/safeguard landscape Education and outreach Culture and heritage
Other findings	Issues
	Barriers to implementation (in order from most common to least) Developments driven by cost and funding priorities Lack of policy drive and legislative support Ability to justify additional costs Reliable assessment of value Awareness of / engagement with the concept of multi-functionality Lack of evidence that benefits will be realised 6 Poor communication between sectors during planning Lack of well-understood 'products' (i.e. ecological engineering solutions) Lack of understanding of ecology of manmade habitats Lack of collaboration with EU/international partners (i.e. knowledge exchange)
Other findings	Opportunities
	Suggestions for moving forward (in order from most suggested to least) Consider multi-functional designs in the planning stage of new defences Strengthen legislative framework Conduct cost-benefit analyses of potential secondary benefits Conduct experimental trials to gather additional evidence Make additional resources available to cover cost of multi-functional features Improve awareness and engagement amongst relevant sectors

	Develop ‘products’ that can be incorporated into scheme designs Develop new technologies to improve potential of multi-functional structures Expand beneficiary pays principal to include secondary benefits Collaborate with EU/international partners (knowledge exchange)
Thoughts/reflections	2: good stakeholder engagement and clear ranking of what stakeholders see as important for costal defense. In terms of current research is simultaneously too specific and to broad. Specific for coastal defense systems but within that there is some mention of artificial reefs etc but also unclear as to which values relate to which types of costal defense structures. However, structures in current research are often multifunctional meaning that this paper can be useful.

Ref ID# 23	Morris et al 2016 (From Kienker et al 2018)
Document type	Peer Reviewed Journal Article
Title	Eco-engineering in urbanised coastal systems: consideration of social values
Summary	Researchers engaged with local community to gain insights into perceptions surrounding modifications to costal seawalls that may result in loss of habitat and marine destruction. The study focuses on costal habitat destruction/environmental issues, the value of the overall marine environment and attitudes towards eco-engineering research.
Geographic region	Sydney, Australia
Structure Type	Flowerpot enhancements to Seawalls
Stakeholders / sectors	Community surrounding the seawall – no specific groupings
Social values explored	The value of Sydney harbour Attitudes towards eco-engineering research Views on coastal habitat destruction/environmental issues
Methods:	What approach was adopted to engage stakeholders
	Survey 1: sent out online during the initial phases of the flowerpots via local community groups and community events. Contained quantitative Likert based closed questions and two open ended questions that asked List three threats to the health of the natural environment in your local area’; ‘In a word or short sentence what comes to mind when you think about the harbor coastline’. Survey 2: sent out during later phases of the flowerpot construction and contained only quantitative Likert based closed questions. Online survey was distributed via local newspapers, council websites, community events Both Surveys: which covered three themes: coastal habitat destruction as an environmental issue; the value of Sydney Harbor marine environment; and (attitudes towards eco-engineering research, in addition to some initial demographic questions
	What approach was adopted to identify and evaluate social values
	Quantitative analysis was conducted on closed question responses. Word clouds were used to assess open ended answers
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	All respondents view the Sydney Harbour as valuable Marine environment is perceived as valuable In survey 1 one half stated that aesthetics was the most important reason for harbour value In survey 2 wildlife was cited as the most important reason for value by just under half of the participants

	Community participation is seen as important for maintaining a healthy harbor environment Disclosing the cost of the flowerpot project had no effect on the views and perceptions of participants
Other findings	Issues
	N/A overall a positive views/perceptions.
Other findings	Opportunities
	Desire for community to be involved in marine research, eco-engineering and interventions Participants willing to compromise aesthetics of structures if it benefited the marine environment
Thoughts/reflections	2: good study that assess a type of man-made marine infrastructure. Only downfall is that stakeholders are not categorised which limits application of findings to broader sense.

	Shafer and Inglis 2000 (From Belhassen et al 2017)
Document type	Peer Reviewed Journal article
Title	**Influence of Social, Biophysical, and Managerial Conditions on Tourism Experiences Within the Great Barrier Reef World Heritage Area**
Summary	Researchers explored the variation between tourism groups visting the great barrier reef (size, duration etc) and if/to what extent social, biophysical and managerial aspects impacted these variations (being close to nature, spending time with family) .
Thoughts/reflections	0: a lot of focus on social values relating to tourism and tourism of natural marine environments. No mention of artificial marine environments. Though social value is discussed it seems out of scope – other MPA articles kept in refer to artificial environments in some way or it is not specifically stated that it is ONLY natural environment. A lot of the engagement influencing factors are also heavily dependent on the environment e.g. weather, types of fish, coral, being close to nature OR things that are not only relatable to tourism and reefs (being close to family) . Removed from review.

	Jentoft 2000 (From Barclay et al 2017)
Document type	Peer Reviewed Journal Article
Title	**Beyond fisheries management: The Phronetic dimension**
Summary	Researcher explores how the changes in development of fisheries and how they are managed. Paper explores if political and social aspects of managing fisheries are as important as technical and scientific aspects and what implications this may have on research and responsibility for managing these fisheries.
Thoughts/reflections	0: seems out of scope – arguing the importance of social science/politics for fisheries and management of fisheries. No stakeholder engagement or measurement of social values relating to man-made aquatic infrastructure. Removed form review.

Ref	Bradshaw, Wood, & Williamson, 2001 (From Barclay et al 2017)
Document type	Peer Reviewed Journal Article
Title	**Applying qualitative and quantitative research: a social impact assessment of a fishery.**
Summary	Study aimed to demonstrate the efficacy of using qualitative and quantitative methods of a social impact assessment to explore a Tasmanian Rock Lobster fishery a social economic profile of a Tasmania Rock Lobster Fishery. Researchers aimed to provide a baseline socioeconomic profile of the Tasmanian rock lobster industry in late 1997 and

	also examine the implication that changes to catch quotas would have on for costal communities.
Thoughts/reflections	0: socioeconomic focus seems to lean more towards economic side than social when building baseline. No man made aquatic infrastructure. Social value that is explore more how changes to catch quota management would impact the community – seems out of scope. Removed from review.

	Barclay 2012
Document type	Literature review, Peer Reviewed Journal Article
Title	The Social in Assessing for Sustainability: Fisheries in Australia
Summary	This paper surveys the literature about sustainability in fisheries, focusing on Australia, and focusing on the way social aspects have been treated. The paper finds that the problems that have been identified for assessing the social in sustainability in general are certainly manifest in fisheries. Management of Australian fisheries has arguably made great improvements to biological sustainability over the last decade, but much remains to be done to generate similar improvements in social sustainability for fishing communities.
Geographic region	Australia
Structure Type	None – general review of fisheries
Stakeholders / sectors	NA
Social values explored	NA
Methods:	What approach was adopted to engage stakeholders
	None – review only
	What approach was adopted to identify and evaluate social values
	None – review only
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Not stated
Other findings	Issues
	A significant challenge for improving sustainability in Australian fisheries lies in improving data collection on social factors, and in bridging disciplinary divides to better integrate social with economic and biological assessments of sustainability. The public and private sector measures remain hampered by the dual problem of insufficient data appropriate for measuring social factors, and misunderstandings of how the social may be integrated with economic and biological assessments of sustainability.
Other findings	Opportunities
	Not stated.
Thoughts/reflections	0: Emphasises the importance of social research, presents outcomes of a review exploring the incorporation of social research into fisheries management. Identifies some relevant resources (e.g. an FRDC report on the value of social research in fisheries management, 2011), but not specific to MMI and does not undertake an empirical assessment of social values.

	Johns et al 2001
Document type	Research Report
Title	Socio- economic study of reefs in Southeast Florida-final report. Report prepared for Broward County, Palm Beach County, Miami-Dade County, Monroe County, Florida

Summary	Investment in and maintenance of public resources is a prime function of government. Artificial and natural reefs are public resources that provide recreational benefits to reef users and income to local economies. This study determined, in a comprehensive manner, the net economic value of southeast Florida's natural and artificial reef resources to the local economies and the reef users. Southeast Florida is defined as the counties of Palm Beach, Broward, Miami-Dade and Monroe. This study area includes, from north to south, the cities of West Palm Beach, Fort Lauderdale, and Miami, and the Florida Keys.
Geographic region	Florida, USA
Structure Type	Artificial Reefs & Natural Reefs
Stakeholders / sectors	Boaters (recreational fishers (commercial fishers were not included), reef divers, reef snorkelers and/or visitors viewing the reefs on glass-bottom boats)
Social values explored	None – focus on socio-economic characteristics, use levels and economic contribution and willingness to pay for management or to invest. The opinions of resident reef-using boat owners regarding the existence or establishment of "no-take" zones as a tool to protect existing artificial and natural reefs were also gathered.
Methods:	What approach was adopted to engage stakeholders
	Conducted four surveys as follows: ß Resident boaters – mail survey conducted in the Fall of 2000 ß General visitors – intercept survey conducted in the Summer of 2000 and the Winter of 2001 ß Visitor boaters – intercept survey conducted in the Summer of 2000 and the Winter of 2001 ß Charter / Party boats – mail survey conducted in the Spring of 2001
	What approach was adopted to identify and evaluate social values
	Quantitative analysis of survey questionnaire
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Majority of resident reef-users endorse the idea of "no-take" zones in their county and in the other southeast Florida counties. A majority of residents would support "no take" zones on 20 to 25 per cent of the existing natural reefs. About 75 precent of respondents in all counties supported the existing "no take" zones in the Florida Keys. About 60 precent of respondents supported "no take" zones in their own counties and about the same percentage supported "no take" zones on some of the reefs in Palm Beach, Broward and Miami-Dade counties.
Other findings	Issues
	N/A
Other findings	Opportunities
	N/A
Thoughts/reflections	0/1 – Economic dominant – obtains perceptions of one management strategy but does not link these to values or differentiate by stakeholder group/respondent type

	Blythe 2015
Document type	Empirical Research, Peer Reviewed Journal Article
Title	Resilience and social thresholds in small-scale fishing communities
Summary	This paper explores resilience and social thresholds in two coastal communities in Mozambique by having fishers define their system identity, identify potential system thresholds, and explain how they would respond to crossing a threshold. A 90 % decline

	in current catch rates would represent a threshold for both communities. Fishers with strong attachment to occupation would respond by migrating permanently to new fishing grounds, whereas fishers with strong attachment to place would respond by changing their professions while remaining in their community. The paper concludes with a discussion of the implications of social threshold data for fisheries governance.
Geographic region	Mozambique
Structure Type	None – general fisheries assessment
Stakeholders / sectors	Local fishermen
Social values explored	Defined system identity, identified potential system thresholds, and explained how they would respond to crossing a threshold.
Methods:	What approach was adopted to engage stakeholders
	Qualitative, semi-structured interviews
	What approach was adopted to identify and evaluate social values
	Interview questions were grouped into three categories. First, fishers were asked to describe the most critical components of their community. The second group of questions focused on system drivers and thresholds. In a scoping trip, fishers identified declining catch rates, the most critical driver of change within the system. Fishers were, therefore, asked to explain how they would respond to sustained 30, 50 and 90 % declines in their current daily catch, based on a methodology developed by Cinner et al. (2011). Fishers were also asked to describe any other stressors or shocks they were experiencing. Finally, fishers were asked to reflect on several possible future scenarios and to describe their preferred state for their community. Interviews were coded based on emergent themes
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Values of fishery explored across elements argued to contribute to system identify. Including components (e.g. family, fish, fishermen, machambas, fishing materials), relationships (e.g. informal social relationships, formal social relationships and socio-ecological relationships), innovation (e.g. ability to target a diversity of species, livelihood diversification, knowledge) and continuity (generations of fishers, closed season). By getting people from within the system of interest define which components are most important to them (e.g., fish and fishers in this case study), identify the drivers of change that pose the greatest threat to those components (e.g., declining catch rates), and describe how they would respond to change in those drivers (e.g., continuing to fish or exiting the fishery) the framework allows researchers to address the dynamic, subjective dimensions of social responses to change.
Other findings	Issues
	N/A
Other findings	Opportunities
	To understand the scope of social responses to change, mixed method, social science analy- ses of experiences, values and desires of people within the system of interest are critical.
Thoughts/reflections	1: An interesting approach by focusing on social thresholds as complementary to ecological thresholds; however, no focus on MMI and does not explore across stakeholder groups (only group only). Presents outcomes of applying a select framework to explore social response to system changes, an approach that may be relevant in later stages of the project???

	Triantafillos et al 2014
Document type	Research Report

Title	**Developing and testing social objectives for fisheries management**
Summary	Little is known about the social dimensions of sustainable fisheries management. In particular, there is little guidance available for fisheries managers to assist them in identifying the social objectives they are managing for, or in collecting information that helps them more successfully manage for these objectives. To address this, this project developed a two-part guide, titled 'Managing the Social Dimensions of Fishing' ('the Guide'). This Guide takes fisheries managers and other key stakeholders through the steps of implementing social objectives, in an ESD context, by helping them identify, document and manage social objectives relevant to their fishery. The Guide also helps fisheries managers identify what aspects of the social dimensions of fisheries they can influence and what factors remain outside their direct influence. This will help fisheries managers better target the identification and management of social objectives to those issues that they can address.
Geographic region	Australia, South Australia
Structure Type	None – not MMI focussed
Stakeholders / sectors	Fisheries
Social values explored	Explores the social objectives relevant to managing fisheries and indicators of relevance for assessing performance against objectives/ Objectives are defined for three 'groups': fishermen, broader community, indigenous persons.
Methods:	What approach was adopted to engage stakeholders
	Multiple: Interviews, surveys, meetings
	What approach was adopted to identify and evaluate social values
	None – social values not specifically targeted, although the social objectives obviously link to the different values of the groups.
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	NA
Other findings	Issues
	N/A
Other findings	Opportunities
	The outcome of the project was a set of recommended social objectives and associated indicators, as well as recommended processes for selecting, measuring, and analysing them in different contexts. The guide provides a tool for those seeking to measure progress towards ecologically sustainable development of fisheries resources.
Thoughts/reflections	1: Not very relevant, does not directly address social values or aquatic infrastructure. But it does provide an overarching framework regarding the social objectives of FRDC (in terms of achieving ESD fisheries management).

	Bohnsack (1989)
Document type	Journal Article
Title	**High densities of fishes at artificial reefs the result of habitat limitation or behavioural preference?**
Thoughts/reflections	0: removed ecological focus only

	Grossman, Jones & Seaman (1997)
Document type	Journal Article
Title	**Do artificial reefs increase regional fish production? A review of existing data.**
Thoughts/reflections	0: removed ecological focus only

Ref ID# 26	Cripps & Aabel (2002)
Document type	Journal Article
Title	Environmental and socio-economic impact assessment of Ekoreef, a multiple platform rigs-to-reefs development
Summary	This paper provides an impact assessment looking at a rigs-to-reef program in Norway. The paper looks at potential short and long term impacts from environmental, ecological, and socio-economic perspectives
Geographic region	Norway
Structure Type	Artificial Reef
Stakeholders / sectors	Not engaged but mentioned: oil and gas companies, fishers (commercial and recreational)
Social values explored	Company reputation, gear, safety, access, licensing
Methods:	What approach was adopted to engage stakeholders
	N/A – impact assessment conducted: look at legislation, impact identification and evaluation, site-specific data -> environmental and socioeconomic impacts -> construction-phase impacts short-term impacts, long term impacts -> design specific impacts (reef design) -> comparison between reefs -> ranking of reef scenarios
	What approach was adopted to identify and evaluate social values
	Semi-quantitative impact severity scale: 0 no effect likely, +1 limited benefits - +3 large and almost immediate benefits, -1 limited effect - -3 serious and long term regional or ecosystem damage
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Socio-economic impacts: *Operating company reputation:* reef creation handled well company may derive benefits. However, if it's handled badly there may be future costs of disposal that exceed creation/restoration costs. (short term impact) *Increased catch:* If fishing effort remains constant, reefs might result in larger catches. However, given current quota regulations, local increases in catch rates should be compensated by lower total effort. (long term impact) *Improved catch security:* Theoretically, reefs may lead to less uncertainty about prospected catch rates. This could result in a more stable income for fishers provided that overfishing is not further exacerbated. (long term impact) *Changes in gear requirements*: To exploit reef resources, alternative gear may be required (e.g. long lines instead of bottom trawls). Depending on the type of gear chosen, this might be a benefit for the environment if the use of more damaging methods becomes restricted. There may be a cost for fishers though. (short term impact) *Gear damage:* fishing close to a artificial reef structure may cause gear damage (long term impact) *Safety:* Entanglement of nets presents a danger to the crew and may lead to the loss of boats. (long term impact) *Limited access:* Reef management for optimizing catches or protecting stocks may require local effort restrictions (long term impact) *Licensing:* The responsibility for control, management and safeguarding of a reef might be delegated to specific fishers co-operatives so that their members would have an interest in sustainable fishing, subject to the full benefits of their actions being internalized rather than being dissipated amongst the wider fishing community. However, exclusion of others could easily lead to conflict and again a legal basis does not presently exist. (long term impact)

Other findings	Issues
	Best options for rigs-to-reefs depending on what perspective you are looking at it form (environmental, ecological, socio-economic)
Other findings	Opportunities
Thoughts/reflections	2 discusses social values from impact assessment standpoint -> stakeholder engagement or if it has it is not gone into detail has not occurred but literature and legislation has been consulted.

	Ajemian et al (2015)
Document type	Journal Article
Title	An Analysis of Artificial Reef Fish Community Structure along the Northwestern Gulf of Mexico Shelf: Potential Impacts of "Rigs-to- Reefs" Programs
Summary	This paper discusses the impact that artificial structures have had on fish populations in the Gulf of Mexico. This was achieved by using ROV dad to study fish assemblages on various artificial oil and gas structures.
Thoughts/reflections	0: ecology fish population as a result of rigs to reefs focus -> one line that says that the study could have potential economic and social values but nothing else

	Edwards (2012)
Document type	Journal Article
Title	Partial vs. Complete Removal: The Debate Surrounding California's Implementation of the Rigs-to-Reef Project
Summary	Paper discusses the two main concerns related to partial or complete removal of oil and gas platforms in California. The first is the environmental impact partial decommissioning will have on the marine environment. The second is the economic benefit that is provided to oil companies and the liability cost that the states who engage in the rigs-to-reef-program. Paper goes into detail around the debate surrounding the rigs-to-reef project form a legal, policy and environmental perspective. Paper also lists group interested in the debate as oil companies, environmental groups, recreational fishermen, and commercial fishermen.
Geographic region	California USA
Structure Type	Oil and Gas Rig, Artificial Reef
Stakeholders / sectors	oil companies, environmental groups, recreational fishermen, and commercial fishermen
Social values explored	Concerns for the environment, concerns over cost
Methods:	What approach was adopted to engage stakeholders
	N/A – overview of development of, implantation of and debate surrounding the rigs-to-reef program
	What approach was adopted to identify and evaluate social values
	Reads like a literature review
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Removal of oil platforms completely is expensive for companies and less so for partial removal Partial removal is also more flexible for oil companies Parties argue that providing oil companies with lower costs after drilling is inequitable

	Environmentalists concerned for impact complete removal has on marine life Generally recreational fishermen are in support of partial removal -> increase in recreational fishing area Trawl fishermen are generally opposed to rigs-to-reef -> loss of area Environmentalists and commercial fishermen concerned with overfishing
Other findings	Issues
Other findings	Opportunities
Thoughts/reflections	1: though not specifically examined, stakeholder groups and their views towards rigs-to-reefs are mentioned – these values are mostly regarding the environment.

	Castello et al 2019
Document type	Journal Article
Title	Sunken Worlds: The Past and Future of Human-Made Reefs in Marine Conservation
Summary	This paper provides history of reef like structures placed in the ocean by humans. It highlights the importance of defining what is meant by a human-made reef. It also highlights the controversy around the cost vs benefit of these structures and the importance of assessing them from social, ecological and structural lenses. Furthermore, the paper argues that these structures should be examined in relation to the role they have on the marine environment rather than just being compared to natural reefs. The paper provides a key on how to identify a diverse initial pool of HMRs at a local or global level, conduct data collection, and carry out systematic assessment of conservation intention and benefits to identify conservation opportunities.
Geographic region	Global
Structure Type	Human-made reefs
Stakeholders / sectors	N/A
Social values explored	N/A
Methods:	What approach was adopted to engage stakeholders
	N/A
	What approach was adopted to identify and evaluate social values
	N/A
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Step 1. Classify as a HMR Based on yes to: is the structure submerged or semi-submerged in the marine environment? Is there evidence that the structure was created by humans, either purposefully or accidentally? Does the structure contain, hard persistent materials (Artworks, prefabricated modules, sunken artefacts, infrastructure, traditional structures) Step 2. Collect and collate data Social data: who created this structure, when and why? How is it used by humans? Structural data: what properties does he structure have? Where is it? Ecological data: how is this structure used by marine life? (general metrics, targeted metrics) Step 3. Systematically assess conservation intention and benefits

	Is there any evidence of intention to create benefits for marine life, indicating available of resource conservation (yes: conservation intention, no: no conservation intention) - Conservation intention +, Conservation benefit - HMRs negating or failing to generate intended conservation benefits - Conservation Intention -, conservation benefit – HMRs with no conservation intention which are negating or not generating conservation benefits - Conservation intention -, Conservation benefit +, HMRs achieving intended social and ecological benefits for conservation - Conservation intention -, conservation benefit + HMRs providing social and ecological benefits for conservation despite lack of stated conservation intention Do the social, ecological and structural characteristics of this structure align with general or targeted conservation goals? (no: harmful or neutral outcome, yes: beneficial outcomes) Step 4 Identify and act on conversation opportunities
Other findings	Issues
	Many arguments relating to HMRs are based on comparisons to natural reefs Conceptualising HMRs as imitations of natural reefs may limit our ability to perceive the unique costs, benefits, and opportunities they present
Other findings	Opportunities
	HMRs can be used to create opportunity for economic growth
Thoughts/reflections	1: Good for definitions and uses of structures. Provides way of classifying HMRs. Gives way of assessing social data -> who, when, why, how? However, no stakeholder engagement or social value assessment.

Professional Literature Review Templates

Ref	INsite (2018)
Document type	Industry Report
Title	The Influence of Man-made Structures in the North Sea (INSITE) Synthesis and Assessment of Phase 1
Summary	This paper discusses the first phase of a project that aims explore the scientific evidencebase needed to better understand the influence of man-made structures on the ecosystem of the North Sea. Specifically, the project wanted to investigate the effects of the structures may have on the spatial and temporal variability of the sea ecosystem and if they are connected in any way. The paper also describes the governance of the committee organising the project.
Thoughts/reflections	0: this paper does not explore stakeholder engagement or social values in MMAI in any way. Removed from review

Ref	Marine Management Organisation (2016a)
Document type	Industry report
Title	Managing commercial fisheries in marine protected areas (MPA) Call for evidence
Summary	Report details assessments carried out on whether certain fishing activities are posing a risk to achieving the conservation objectives for marine protected areas (MPAs) in English inshore waters. These assessments were conducted to inform whether additional management action should be taken to help safeguard the environment and ecosystem in these areas.
Geographic region	UK
Structure Type	Marine Protected Areas

Stakeholders / sectors	Not specified – potentially fishing communities
Social values explored	Ecological/environmental sustainability
Methods:	What approach was adopted to engage stakeholders
	Awareness of the consultation was raised through various methods including: news stories, government websites, an online questionnaire, flyers, information in fishing magazines, Facebook and other social media, fishing agencies, direct emails The consultation asked for feedback via an online questionnaire that asked which management option is deemed most appropriate: Option 1: Introduce a monitoring and control plan within the site to monitor current and potential fishing activities Option 2: Reduce or limit levels of fishing activities within the site Option 3: Prohibit fishing activities on features within the site
	What approach was adopted to identify and evaluate social values
	Information/feedback received summarized and responded to
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Certain types of fishing gear use should be limited to protect the ecosystem and biodiversity Concerns over unclear sources that map sea floor composition and fish composition in certain areas MPA management should be concerned with maintaining physical habitats Reducing or limiting fishing in certain sites
Thoughts/reflections	1: stakeholder consultation exploring ecology/environmental impacts of fishing. Social value in the form of concern for the environment can potentially be inferred but is limited.

Ref	Marine Management Organisation (2016b)
Document type	Industry report
Title	Stakeholder engagement to assess the economic impact of the South marine plans
Summary	Report details the assessment of the economic impact on industry of the three South Inshore and South Offshore marine plan options in the UK. Stakeholder and industry bodies were interviewed to gain insight into this impact – economic value is considered in terms of impact on businesses, employees, gross added value to the marine sector and administrative impact. Findings were categorised into administrative impacts, economic impacts and environmental impacts. All 3 proposed plans amounted in economic benefit.
Thoughts/reflections	0: economic focus only no social value. Plans for change but no MMAI removed from review

Ref	Marine Management Organisation (2011)
Document type	Industry report
Title	Maximising the socio-economic benefits of marine planning for English coastal communities
Summary	This report was made in order to help marine planners adhere to marine policy. This is achieved by exploring the socio-economic processes that are present within coastal communities. Additionally the report provides an understanding of the socio-economic impacts of marine activities in coastal communities and suggestions about how these can be positively maximised. The report made a point to state they are not looking at the social impact from the areas of: broad environmental impact, local culture/community, wellbeing, or health. Report also states that economic value will be at the forefront while social impacts will be used to explain economic value.

Thoughts/reflections	0: though paper claims to explore social impact it is very lacking in terms of our definition of social impact. Primarily an economic focus and no mention of MMAI

Ref	Marine Management Organisation (2019)
Document type	Industry Report
Title	You said, we did: Summary of stakeholder led Iteration 3 policy changes
Summary	Summary of workshops held exploring stakeholder perceptions and desired improvements to marine policy and marine development. 3 iterations of stakeholder engagement were conducted.
Thoughts/reflections	0: focus on marine policy not MMAI. Perceptions of policy changes rather than of social value. Removed from review.

Ref	Oil and Gas Authority (2011)
Document type	Industry Report
Title	Decommissioning Delivery Program
Summary	This paper describes a program that was put in place to deliver the decommissioning strategy in the UK. The report also describes in how and when near-term priority areas in decommissioning will be delivered. The program described in the report takes into account the various obligations and commitments from industry bodies in the oil and gas sector. The paper describes the importance of consultation during decommissioning and related objectives.
Thoughts/reflections	0: no social value, MMAI or stakeholder consultation

Ref	Marine Scotland (2011)
Document type	Industry Report
Title	A STRATEGY FOR MARINE NATURE CONSERVATION IN SCOTLAND'S SEAS
Summary	This report aims to describe current objectives for protecting the environment and biodiversity of Scotland's marine life in accordance with government policy. This focuses on 3 pillars that include: species conservation, site protection, wider seas police and measures.
Thoughts/reflections	0: no social value, MMAI or stakeholder consultation

Ref	Marine Scotland (2019)
Document type	Industry report
Title	Future of fisheries management in Scotland: national discussion paper
Summary	This report explores the future of fisheries in Scotland in terms of fishing opportunities, access to fish, inshore fisheries, funding, labour, innovation, science and technology. A particular focus is put on Brexit and how this will impact the Scottish commercial fishing industry. Paper begins by describing themes that emerged from initial stakeholder consultation and then asks individual readers to comment on the rest of the paper throughout.
Geographic region	UK
Structure Type	Fisheries
Stakeholders / sectors	Environmental groups, fishers, local authorities, industry professionals
Social values explored	Broad environmental and industry values can be inferred but are not explored specifically
Methods:	What approach was adopted to engage stakeholders
	Initial dialogue with stakeholders to set the scene and highlight key themes and concerns with stakeholders

	What approach was adopted to identify and evaluate social values
	Potentially some sort of low level thematic analysis
Findings	**Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]**
	Fishing in a responsible and sustainable way Robust evidence needed to establish fishing opportunities Removal of barriers to prevent fishing sector from growing and diversifying
Thoughts/reflections	1: stakeholder consultation exploring perceptions of impacts of commercial fisheries and how best to move the industry forward. Social value in the form of concern for the environment /sustainability and industry can potentially be inferred but is limited.

Ref	Marine Scotland (2018)
Document type	Industry Report
Title	**Report of The Scottish Coastal Forum's National Marine Plan Review Workshop held on behalf of Marine Scotland on 29 September 2017**
Summary	Description of a workshop held to explore the Scottish governments' National Marine plan in terms of: Implementation and effectiveness of the Plan; Emerging and new marine activities; Changing policy landscape; and Use of information and data sources.
Thoughts/reflections	0: social value of MMAI not explored. Note that more research is needed into the social value of marine planning and policy.

Ref	Marine Scotland (2011a)
Document type	Industry Report
Title	**A review of marine social and economic data**
Summary	This report lists and describes the availability of marine economic and social data so that it may be used to facilitate decision making for marine planning and licensing. Gaps and weaknesses within the data set are identified. Social value data is defined as: "Data relating to the characteristics of coastal and linked marine communities: employment, demographics, business base, health and wellbeing data including access to recreational and leisure facilities, wealth / deprivation indices, quality of life indicators" (p. 4).
Geographic region	UK
Structure Type	Marine Planning
Stakeholders / sectors	N/A
Social values explored	employment, demographics, business base, health and wellbeing data including access to recreational and leisure facilities, wealth / deprivation indices, quality of life indicators
Methods:	**What approach was adopted to engage stakeholders**
	Literature review of available data sets
	What approach was adopted to identify and evaluate social values
	Prepare and review a catalogue of marine social and economic data: 1. Development of catalogue attributes 2. Initial preparation of catalogue from key datasets 3. Prioritisation of data sources 4. Consultation with the marine community

	5. Review and assessment of data
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Social value data sets were found in the following data categories: costal defence, education, fisheries, marine time transport, 'social' Social value in oil and gas, renewable energy, research, and leisure/recreation is missing
Thoughts/reflections	1: could be useful for justifying a lack of data

Ref	Marine Scotland (2011b)
Document type	
Title	Marine social and economic data: A critical review of tools and methods to apply marine social and economic data to decision making
Summary	Review of socioeconomic data bases that were found in study discussed about and evaluation of how they can be used as tools for decision making in marine planning in terms of: understanding the problem that needs management, data mapping and visualisation, development of policy or development options, selection of sites to meet policy or development objectives, assessment of the economic and social impacts of policy and development options, monitoring and evaluation of policy objectives, targets and licensing conditions.
Thoughts/reflections	0: marine planning and policy focus and application of data from decision making. No MMAI focus.

Ref	CRC Reef Research Centre (2002)
Document type	Technical Report
Title	Marine tourism impacts and their management on the Great Barrier Reef
Summary	Paper is a literature review of social, economic and cultural impacts that tourism has on the great barrier reef.
Geographic region	GBR, Queensland
Structure Type	Natural Reef
Stakeholders / sectors	N/A reads like a literature review
Social values explored	coastal tourism development (population pressures, construction activities); island-based tourism infrastructure (marinas, sewage discharge, construction); marine-based tourism infrastructure (pontoons, moorings, fish feeding); boat-induced damage (anchoring, ship grounding, litter, waste discharge); water based activities (diving, snorkelling, reef walking, fishing); wildlife interactions (seabirds, turtle-watching, whale-watching).
Methods:	What approach was adopted to engage stakeholders
	N/A
	What approach was adopted to identify and evaluate social values
	Literature review
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	mismatch between public perceptions of tourism as a threat to the GBR, relative to other broad scale impacts. "there have been relatively few studies of social and cultural impacts relative to the studies of ecological impacts" (p. 20)

Thoughts/reflections	1: reads more like a literature review rather than completing research of their own. Snowballing articles found from it for academic review however they all focus on non-artificial marine infrastructure.

Ref	CRC Reef Research Centre (2005)
Document type	Technical Report
Title	POTENTIAL EFFECTS OF ARTIFICIAL REEFS ON THE GREAT BARRIER REEF: BACKGROUND PAPER
Summary	This paper discusses key gaps, issues and potential problems in literature surrounding the effects that artificial reefs may have on the great barrier reef and gives recommendations as to how these can be addressed. Paper also provides a definition of artificial reef and applications of artificial reefs.
Geographic region	GBR, Queensland
Structure Type	Natural Reef and Artificial reefs
Stakeholders / sectors	N/A
Social values explored	The values and motivations underlying the potential social and/or economic benefits of artificial reefs (e.g. enhanced fishing experiences); The likelihood of artificial reefs effectively addressing those values
Methods:	What approach was adopted to engage stakeholders
	N/A
	What approach was adopted to identify and evaluate social values
	N/A
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Key information should be sought as a basis for any developments. In particular: Clear documentation of stakeholder needs: Who wants what, why, and what is the best way to satisfy them Artificial reefs may potentially enhance diving/tourism opportunities in several ways by providing: a focus and guaranteed experience for recreational divers; convenient, all weather access to dive sites; and new marketing/economic opportunities for local communities
Thoughts/reflections	1: paper focuses mostly on potential ecological/environmental issues of AR near the GBR. Social values are addressed mostly in terms of a cost-benefit analysis. As no experiment was conducted a lot of what they say is speculation – further research needs to be conducted to asses gaps they have highlighted. Useful definition and application of artificial reefs

Ref	WAFIC (2017)
Document type	Industry Report
Title	Thevenard Offshore Platform Retirement Commercial Fishing Sector Stakeholder Consultation – WAFIC Report
Summary	This paper details a stakeholder consultation plan created to involve the commercial fishing sector in the next phases of the Chevron Thevenard Offshore Platform Retirement project. This consultation aimed determine commercial fisher views on full removal of, or partial retention of infrastructure.
Geographic region	WA
Structure Type	Oil and Gas Platform
Stakeholders / sectors	Commercial Fishers

Social values explored	Values associated with removal of oil and gas infrastructure
Methods:	**What approach was adopted to engage stakeholders**
	Identified relevant commercial fishing stakeholders specific to the scope of the Thevenard Offshore Platform Retirement project On behalf of Chevron, distributed relevant information provided by Chevron about the scope and impact of the Thevenard Offshore Platform Retirement project to identified relevant stakeholders Provided to Chevron all feedback, responses and statements of claim to enable Chevron to address commercial fishing sector concerns
	What approach was adopted to identify and evaluate social values
	Not specifically stated – key/salient points from stakeholder feedback are summarized
Findings	**Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]**
	Destruction and or disruption of the benthic environment is a major concern: complete removal will impact fishing activities, impact fishing for the duration of the removal activities Contamination concerns: no toxic materials should be left to avoid environmental risk Vessel: will the structures left below impact their vessels? How can they be avoided? Safety risks, loss of gear Positive attributes of leaving structures behind will: will be beneficial for some fisheries, potentially benefit future fishing activities, beneficial for recreational fishing, open up new fishing sites, breeding sites Safety concerns: damage to vessels causing fatalities Artificial reefs: improve overall marine environment, wont necessarily benefit fisheries , damage gear Exclusion Zones: always an issue for commercial fishers
Thoughts/reflections	2. explores stakeholder views on MMAI but no in-depth analysis of what the social values are – could be inferred but more detail is needed

Ref	WAMSI
Document type	Industry Report
Title	**Decommissioning offshore infrastructure: a review of stakeholder views and science priorities**
Summary	This report details the concerns, opportunities and issues that stakeholders towards decommissioning options. This consultation is being conducted within the context of the blueprint for marine science.
Geographic region	WA and Canberra
Structure Type	Oil and Gas Platforms
Stakeholders / sectors	Commercial fishers, recreational fishers, tourism, community, conservation, indigenous, government regulators, state government agencies, commonwealth government agencies, science
Social values explored	Environmental, safety, maintenance, resources, community, connectivity
Methods:	**What approach was adopted to engage stakeholders**
	Semi-structured interviews and workshops with more than 120 stakeholders and association representatives from multiple sectors and the community from Perth, Exmouth, Karratha, Dampier, Port Sampson and Canberra

	Prompts for discussion: Environment, Shipping & navigation, Fishing, Tourism, Depth, location & weight, Waste, Safety & technical feasibility, Disposal / recycling / reuse, Research & education
	What approach was adopted to identify and evaluate social values
	Discussions were assessed by themes then divided by sectors The prioritisation was completed in workshops that included experts from the regulation, industry, management and research sectors involved in different aspects of decommissioning. The people involved well placed to identify how the different stakeholder identified questions, once addressed, would improve regulatory and operational processes and therefore their relevant priority. Prioritisation was completed by considering the questions derived from stakeholder engagement against a framework of value provided by answering those questions. The framework considers the value in the context of drivers drawn from the Blueprint Implementation Strategy of: • efficient and effective policy and regulation • cost efficiency for industry • social license to operate for both industry and government • multi-sector benefits from improved approaches
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Main issues: Environmental issues – productivity, impacts, invasive species Safety and risk issues - navigation hazards, issues relating to hook-ups, visibility Maintenance issues - corrosion/contamination, stability, pollution, end of line responsibility, liability for ongoing maintenance Resource sharing issues –competing sectors, exclusion zones, information transparency, flow on benefits from cost savings Opportunities for future uses, reefing, tourism development, accommodation Economic issues - opportunities (business), liability Aesthetics and accessibility Case by case considerations Recycling Connectivity and interrelationships - environmental, social, cultural & economic - all options of decommissioning Community acceptance of decommissioning approach Prioritisation (High, medium, low) Environmental effect 1. What are the direct impacts on important fish species including from contamination, noise, habitat removal and resulting cumulative ecological effects? (H) 2. What is the timeframe and breakdown (corrosion rates) of the various components of oil and gas infrastructure? (H) 3. What are the main contaminants following decommissioning, will they be released into the environment, and what are the toxicity issues? (H)

	4. Can the contaminants resulting from decommissioning be completely removed e.g. from sludges, scale, sands and drill cuttings? (H) Benefits to be realised 1. Does oil and gas infrastructure (pipelines and jackets) increase productivity of key fish species and biodiversity generally? (H) 2. What are the economic benefits to local and regional communities for all options of decommissioning? (H) 3. What types of infrastructure maximises benefits for fishing and other recreational activities? (M) 4. Can existing infrastructure be enhanced to optimise fishing and other recreational activities? (L) 5. Are there alternative opportunities for decommissioned infrastructure (e.g. tourism, recycling, reefing elsewhere)? (L) Risks 1. What are the navigation issues with regards to options other than 'full removal'? (H) 2. Is there connectivity between structures and does this provide 'stepping stones' for introduced marine pests? (H) 3. Do introduced marine pests colonise oil and gas infrastructure more readily than natural structures? (M) 4. Does oil and gas infrastructure act as refugia (fish, mammals, birds) and what are the risks to these species on removal? (L) 5. Over time, what are the risks of 'toppled' or 'reefed' structures becoming unstable or moving and creating hazards for trawlers, other vessels and recreational interests? (H) 6. What are the human health and safety issues associated with decommissioning? (L) Management 1. What is an agreed approach to quantifying the benefits of decommissioning options? (H) 2. Is it possible to measure the cumulative regional impacts of decommissioning options? (H) 3. Are there efficient and effective monitoring processes to gauge effects of decommissioning options over time? (M) 4. If there are cost savings for decommissioning options (e.g. reefing), will there be flow-on benefits for the community? (M) 5. Are there management processes in place to deal with resource sharing issues with various decommissioning options? (L) 6. Will the future design of offshore infrastructure be informed by a range of decommissioning options? (L) The key non-scientific issues that may need to be addressed to support orderly decommissioning activities include: • Liability, including future environmental and navigation issues • Resource sharing between commercial fishers, recreational fishers and conservation • Opportunities of enhanced fisheries and or habitats created • Consideration that any science program should improve the fundamental knowledge of decommissioning effects and underpin an improvement across all assessments • Concern that when resource companies are on-sold, the capacity and resources for complete removal or other costly decommissioning options may not be available.
Thoughts/reflections	3: explores stakeholder values in relation to decommissioning. Furthers exploration by completing prioritisation.

Ref	Chevron (2017)
Document type	Industry Report
Title	Gorgon Gas Development Marine Environmental Quality Management Plan
Summary	The purpose of this document is to gather information about the environmental and ecological impacts of developing the gas reserves of the Greater Gorgon Area. While the document focuses mostly on the spatial and ecological aspects of the development some stakeholder engagement and social values are discussed.
Geographic region	Onslow West Australia
Structure Type	Oil and Gas Platform
Stakeholders / sectors	Industry bodies
Social values explored	Fishing and Aquaculture, recreation, cultural, industry and tenure, marine protected areas
Methods:	What approach was adopted to engage stakeholders
	Chevron Australia informed OEPA and Parks and Wildlife of its intention of development of this Plan. Return correspondence received from OEPA Chevron Australia briefed OEPA and Parks and Wildlife on 23 October 2014 regarding the proposed implementation The presentation material was provided electronically to OEPA and Parks and Wildlife after the briefing.
	What approach was adopted to identify and evaluate social values
	Unclear
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	There are no aquaculture activities in the waters surrounding Barrow Island – minimal impact to aquaculture Tourism around this area is low but increasing Aboriginal land significance incorporated into development plan No residential areas around the island that could be impacted May be within a marine protected area
Thoughts/reflections	1: very technical report. Some mention of social values but no clear engagement with groups they are speaking for – not clear where social value information has come from. More so talking about how they MAY be impacted. Main focus is not social value related to MMAI

Ref	CRC Reef Research Centre (1999)
Document type	Technical report
Title	Understanding public perceptions of the Great Barrier Reef and its management
Summary	This paper describes a research process conducted to determine participants experience with the Great Barrier reef. Perceptions of the current and future state of the reef, threats to and attitudes towards reef protection were examined. The aim of the study was to assist/contribute to development of reef interpretive activities and produce data that could be used by management agencies and operators associated with the Great Barrier Reef.
Geographic region	Australia – Melbourne, Sydney, Brisbane and Canberra
Structure Type	Natural Reef – GBR
Stakeholders / sectors	Not specified
Social values explored	Perceptions of the current and future state of the reef, threats to the reef and attitudes towards reef protection

Methods:	What approach was adopted to engage stakeholders
	Mixed-methods telephone survey from a random sample Topics examined in the survey included: Understanding of the World Heritage status of the GBR, Knowledge of what was allowed within the Great Barrier Reef Marine Park, Perceptions of threats to the GBR, in particular knowledge and perceptions of negative impacts, Perceptions of the GBR, including images of the GBR, reasons for its protection, and it's current and likely future status, and Major channels used for information about the GBR.
	What approach was adopted to identify and evaluate social values
	Mixed methods analysis of the responses
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	40% of the respondents had never visited the reef site – of those participants 40% of them had no intention to visit the site Snorkelling, swimming, fishing, Scuba diving, general sightseeing, glass bottom boat, coral/fish viewing, reef walking, sailing, visit islands (most preferred activities from highest to lowest) Most popular words to describe the reef were beautiful, splendid and unique 53% of particpants felt the reef was currently in good condition %1% felt that in 10 years it would be in worse condition than it is now Pessimism in relation to the GBR is high Threats to the GBR were perceived to be pollution/rubbish (55%), general human impact (38%), tourism/tourists (36%) and the Crown-of-Thorns (34%) 69% of respondents believe it is the governments' responsibility for managing the reef 77% believe the reef should be protected as it is a unique natural environment Major sources of information about the GBR include: television, friends/relatives, personal experience, and magazines
Thoughts/reflections	2: explores perceptions/social values in relation to a natural reef rather than MMAI but is within an Australian context. Details activity preferences for reefs. Idea of pessimism in relation to the GBR – does this carry over to other marine structures?

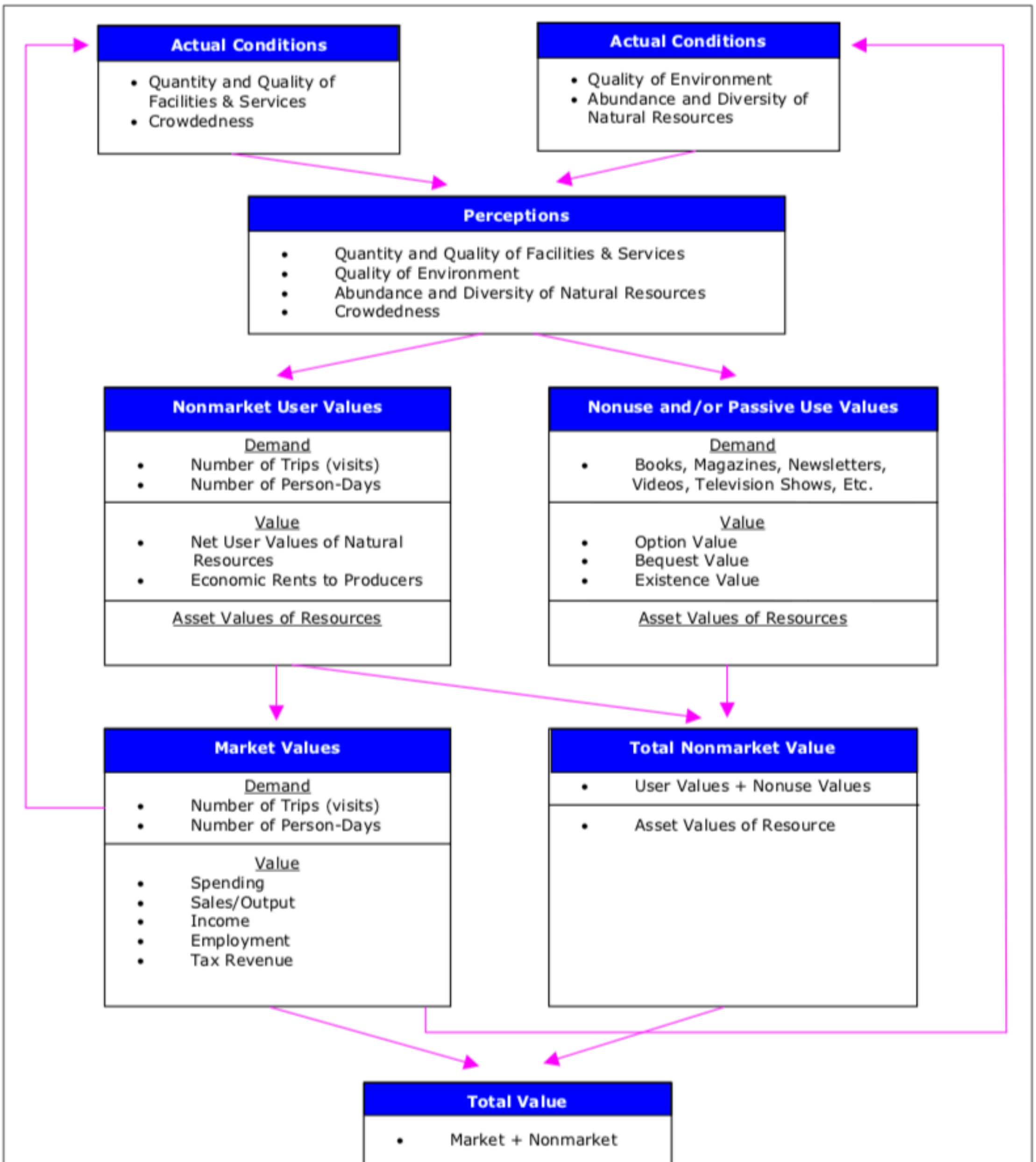
Ref	CRC Reef Research Centre (1998)
Document type	Technical Report
Title	**Visitor experiences and perceived conditions on day trips to the Great Barrier Reef**
Summary	This report details the experiences had by day-trip visitors to the Great Barrier Reef and the conditions that they were influenced by. This purpose of this was to determine the qualities/benefits that visitors want from a trip to the reef. Additionally, researchers wished to determine the attainment of these benefits is changed by natural and social environments experienced on the trip.
Geographic region	Australia – GBR
Structure Type	Natural Reef – GBR
Stakeholders / sectors	Not specified – respondents tourists from Australia, Japan, Britain and the US
Social values explored	Benefits/experiences of visiting natural reefs

	Influence of biological and social conditions on experiences Social carrying capacity: as a level of use beyond which a person's experience in an environment was negatively affected by other users Carrying capacity for tourism: carrying capacity has been used to describe relationships between use and environmental change at two different scales
Methods:	What approach was adopted to engage stakeholders
	Self-administered mixed methods questionnaire completed by day-trip visitors to the GBR Participants asked to rate how much the trip provided them with different benefits as a part of their experiences (e.g., get some exercise, meet people, learn about a coral reef) and the influence that different physical, biological and social conditions had on their enjoyment of the trip. The first section asked visitors to respond to open ended questions regarding things that "added to" or "detracted from" their reef experience The second section of the survey asked visitors to provide information about past visitation/experience on the GBR and/or at other reef sites The third and fourth sections of the questionnaire queried visitor perceptions about the reef site and the nature of the experience they had enjoyed.
	What approach was adopted to identify and evaluate social values
	Mixed methods analysis of the responses – factor analysis, LAC process
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Four main classes of benefits: experiencing nature, relaxing and escaping from normal routines, excitement with family and friends, and being physically active Five general types of reef visitors based on benefit classes: people who predominantly escaped from their normal routine and experienced nature, visitors who shared their experience of the natural environment with friends and family, those who experienced nature without taking part in physical activities (e.g. snorkelling), people who were very enthusiastic about all aspects of the trip, and people who were generally not enthusiastic about any particular part of the trip Natural conditions at the visited sites were the most important influences on enjoyment of the trip notable differences between large and small operations in the benefits visitors received from travelling to the reef and in their perceptions of a quality experience – mostly related to social conditions present during the trip Activities completed on the tours: underwater observatory, semi-submersible ride, snorkelling, scuba diving Perceptions of 9 potential uses of values (highest to lowest value): conservation opportunities, natural processes, educational opportunities, scientific research, cultural heritage, historical meaning, economical opportunities, spiritual meaning Visitors' perceptions of how much their trip to the GBRMP provided 16 possible benefits (from highest to lowest): Experience the beauty of nature, Be in a natural place, Experience something new and different, Experience an undeveloped environment, Learn about a coral reef, Learn more about nature, Escape the normal routine, Have some excitement, Rest and relax, Be physically active, Be close to friends or family, Be with others who enjoy things that I enjoy, Get some exercise, Meet new people, Develop skills and Experience some solitude Visitor perceptions of the influence of 24 conditions on their experience (from highest to lowest): Helpfulness of the staff, Types of fish I saw, Size of the coral I saw, Total amount of coral I saw, Number of different kinds of coral, Information provided by the staff, Colour of the fish I saw, Clarity (visibility) of the ocean water, Colour of the corals I saw, Appearance of

	the staff, Total number of fish I saw, Behaviour of the fish, Size of the fish I saw, Temperature of the air, Depth of the water, Temperature of the water, Number of animals other than coral or fish that I saw, Sea conditions during the trip from/to shore, Number of people on the main boat, Number of people snorkelling, Currents in the water around the reef, Number of people on the pontoon, Amount of wind, Number of human-made objects in the water
Thoughts/reflections	2: in depth analysis of factors that can influence experience and benefits associated with visiting a reef site. No mention of MMAI

Ref [1]	Leeworthy, Wiley and Hospital 2004
Document type	Report
Title	**Visitor Importance-Satisfaction Ratings: A Five-year Comparison**
Summary	Presents summarised results of a Recreation and Tourism survey undertaken as part of the Socioeconomic Research and Monitoring Program for the Florida Keys National Marine Sanctuary. Compared findings of survey initially undertaken in 1995-96 with results of current survey (2000-2001)
Geographic region	Florida USA
Structure Type	Artificial and Natural reefs
Stakeholders / sectors	Users, defined as 'boating' and 'experienced' >5yrs , 'unexperienced' <5yrs, visitor, resident
Social values explored	Perceptions of importance and satisfaction with natural resources (inc. artificial reefs)
Methods:	What approach was adopted to engage stakeholders
	Survey
	What approach was adopted to identify and evaluate social values
	Quantitative survey analysis
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Increase in the attributes identified as important Experience visitors have higher importance scores and less satisfaction than less experienced visitors Decline in boating satisfaction in 2001 compared to 1996 Key areas of concern identified across the themes of natural resources (amount of coral, diversity in species, large wildlife viewing, beach quality), natural resource facilities (shoreline access, parks and protected areas), other facilities (directional signs, cleanliness of streets and sidewalks, uncrowded conditions) and services (e.g. value for price).
Other findings	Issues
	There were additional issues of concern in 2000/1 compared to 1996, despite measureable improvements in environmental condition. Suggest communication needed to raise awareness of positive env conditions/ outcomes. Talks about the value of understanding change in perceptions over time with respect to making management changes to improve perceptions prior to 'value loss'.
Thoughts/reflections	Contains a model linking the economy and environment, drawn from report by Leeworthy and Bowker 1997 (a copy is in the professional literature folder), which might be useful when integrating the economic and social value components of our work.

Figure 13. Conceptual Model Linking the Economy and the Environment



Source: Leeworthy and Bowker 1997

Ref [1]	Montes et al 2019
Document type	Empirical assessment, Peer-reviewed literature
Title	Influence of fish aggregating devices on the livelihood assets of artisanal T fishers in the Caribbean
Summary	Use of moored FADs has been actively promoted in artisanal fisheries, including those of many island nations, in order to increase food security, improve livelihoods and safety-at-sea for fishers. Using structured face-to-face interviews of 316 artisanal coastal fishers across five Eastern Caribbean island nations, we studied perceived and self-reported livelihood assets (natural, financial, physical, social and human) of non-users, long-term users and recent adopters of moored FAD fishing.

Geographic region	Caribbean: Antigua & Barbuda, Dominica, St. Lucia, St. Vincent & the Grenadines, and Grenada
Structure Type	Moored FADs = manmade structures that attract pelagic fish, thereby aggregating the thinly distributed resource in a known location where it can be effectively targeted.
Stakeholders / sectors	Non-users, long-term users and recent adopters of moored FAD fishing. The fishery sector is artisanal or small- scale commercial in nature.
Social values explored	Self-reported livelihood assets (natural, financial, physical, social and human)
Methods:	What approach was adopted to engage stakeholders
	Structured face-to-face interviews of 316 artisanal coastal fishers. The survey sample was determined from estimates of the number of moored FADs, general fishermen population, and moored FAD fishers based on reports from the CRFM (2015), FAO (2016), and personal communication with local Fisheries Officers.
	What approach was adopted to identify and evaluate social values
	The questionnaire, which guided the interviews, captured fishers' general perceptions about attributes of wellbeing that characterized various livelihood assets. Survey questions were designed to allow for an appraisal of current (during the past year) and past (from one to five years ago) wellbeing using a common set of assets outlined in the sustainable livelihoods framework. The selection of survey questions was facilitated by borrowing and adapting items from similar studies, which were found to contribute significantly towards measuring changes in the status of wellbeing
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Physical and social assets showed a perceived increase over the five-year timeframe, and natural and the financial assets were considered to have decreased over the five-year timeframe Fishers who did not fish around moored FADs during the past year gave lower scores for the natural and financial assets than fishers using moored FADs during the past year.
Other findings	Issues / Opportunities
	Used findings to provide recommendations to increase livelihood assets across the categories of social, human, natural and financial/physical assets
Thoughts/reflections	Not specific to the held values we are exploring, but addresses multiple elements contributing to well-being and compares across stakeholder/user type. This is a journal article, but was sourced from location of professional literature and published post our academic literature review (1 Sept 2019) and was therefore included.

Ref [1]	Bates 2016
Document type	PhD Thesis
Title	**Key Challenges of Offshore Wind Power: Three Essays Addressing Public Acceptance, Stakeholder Conflict, and Wildlife Impacts**
Summary	This dissertation addresses social and regulatory issues surrounding offshore wind development through three stand-alone essays, which, in combination, address a decision-making framework of where to locate offshore wind turbines, by minimizing effects on people and wildlife. The challenges to offshore wind that are addressed by this dissertation include (1) understanding underlying factors that drive support for or opposition to offshore wind energy; (2) conflict with existing ocean uses and users; and (3) public concern and regulatory processes related to wildlife impacts.
Geographic region	USA - Atlantic City, New Jersey and coastal Delaware
Structure Type	Offshore Wind Farms
Stakeholders / sectors	Community residents

Social values explored	Support and opposition towards wind farms, factors influencing support or opposition
Methods:	What approach was adopted to engage stakeholders
	Used a random probability sample and obtained addresses from the sampling firm Survey Sampling International.
	What approach was adopted to identify and evaluate social values
	Survey of 699 residents in greater Atlantic City, New Jersey and coastal Delaware, United States, where near-shore wind demonstration projects had been proposed.
Findings	Social values [interrelationships, variability across stakeholder groups, potential impacts on or opportunities for]
	Strong majority of the public supports near-shore demonstration wind projects in both states. Primary reasons for support include benefits to wildlife, cost of electricity, and job creation, while the primary reasons for opposition include wildlife impacts, aesthetics, tourism, and user conflicts. These factors differ between coastal Delaware and greater Atlantic City and highlight the importance of local, community engagement in the early stages of development. In Atlantic City, demonstration projects may be seen as further industrialization of the ocean and conflicting with the traditional uses of the ocean, and therefore inconsistent with their notion of the ocean. Conversely, in Delaware, residents with a strong ocean identity likely see the demonstration project symbolizing clean energy, consistent with the nature and stewardship.
Other findings	Issues / Opportunities
	While it is evident that coastal communities are generally supportive of offshore wind development, those opinions are nuanced and a number of factors are likely to be relevant as to whether communities comes together in support of a local project, or reject such a proposal. These nuanced findings signify that coastal communities are not uniform and care should be taken to understand these nuances early in the planning process of offshore wind energy.
Thoughts/reflections	Content above focuses on the first essay in the thesis, as the second two were not closely related to our topic. The second essay looking at conflicts, a spatial assessment, comparing areas valuable to wind power generation with those areas valuable to commercial fishing.

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

Appendix 3 Social and commercial surveys

Carmen Elrick-Barr & Julian Clifton

This appendix is part of the final report for:

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

Euan S. Harvey, Fran Ackermann, Michael Burton, Julian Clifton, Carmen Elrick-Barr, Johanna Zimmerhackel, Georgina Hill, Stephen J Newman, Jenny Shaw, Mark Pagano, Paul McLeod, Dianne McLean, Julian Partridge

24th August 2021

FRDC Project No **2018-053**

This appendix reports some summary statistics from the online Social Survey, and a record of the full Social and Commercial Fishers surveys.

Survey respondent profile

Table 1 Stakeholder groups represented in the social value surveys

	All Responses		Completed Surveys	
	Number	**%**	**Number**	**%**
Recreational fishermen	353	64.2	309	70.1
Diver	90	16.4	81	18.3
Other	41	7.5	28	6.3
Commercial fishermen	27	4.9	23	5.2
Not stated	39	7.1	0	0
Total	550	100.0	441	100

Note: For the purpose of analysis, incomplete survey responses were removed.

Table 2 Profile of 'Other' respondents

		Total	%
	Local government	3	6.8
	State government	2	4.5
	Private sector	3	6.8
	NGO	4	9.1
	Research	8	18.2
	Tourism	17	38.6
	Other*	7	15.9
Total		44	100

* Others include: Local community/resident (4); Environmental; Commercial fishing; Local tourism

Table 3 Age distribution by stakeholder group

	Stakeholder Group					Total
Age	Not stated	Comm Fish	Dive	Rec fish	Other	
15-19	0	0	1	8	3	12
20-24	2	0	10	18	9	39
25-29	1	0	14	22	2	39
30-34	3	4	14	41	9	71
35-39	2	0	13	40	9	64
40-44	1	1	3	39	2	46
45-49	2	0	6	42	0	50
50-54	3	7	13	42	5	70
55-59	1	2	9	36	1	49
60-64	1	4	2	31	0	38
65-69	1	4	2	15	1	23
70-74	0	2	0	9	0	11
75 and over	1	2	0	7	0	10
Total	18	26	87	350	41	522

Table 4 Respondent gender by stakeholder group

	Male	Female	Total
Not stated	9	7	16
Commercial fisher	24	3	27
Diver	58	29	87
Recreational fisher	303	39	342
Other	17	24	41
Total	411	102	513

Recreational fishing respondent profile

Table 5 Forms of recreational fishing most frequently undertaken.

	Frequency	Percent	Valid Percent	Cumulative Percent
Collection by hand	3	0.5	.9	.9
Line fishing from a boat	221	40.2	62.8	63.6
Line fishing from the shore	114	20.7	32.4	96.0
Net fishing	2	0.4	.6	96.6
Pot fishing	8	1.5	2.3	98.9
Spear fishing	4	0.7	1.1	100.0
Total	352	64.0	100.0	
Missing	198	36.0		
Total	550	100.0		

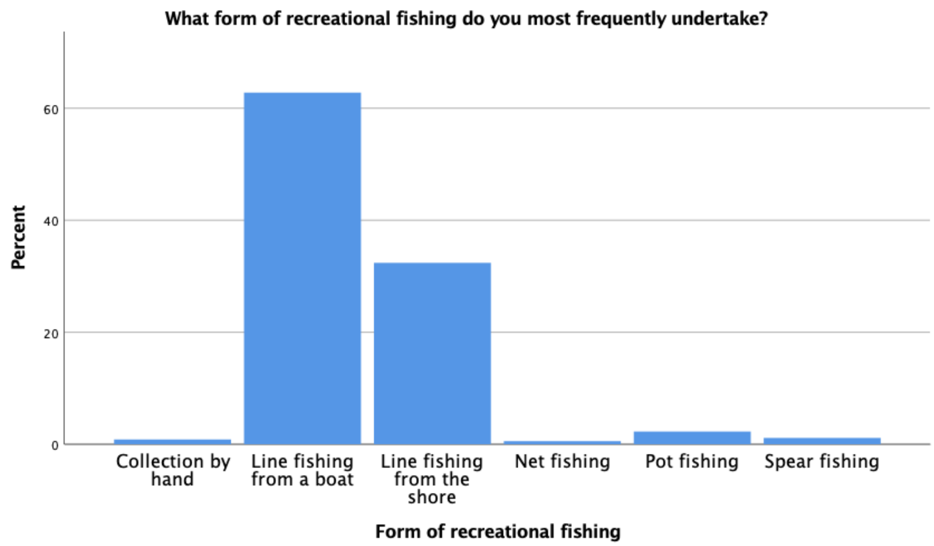


Figure 1 The forms of recreational fishing most frequently undertaken by recreational fishing survey respondents.

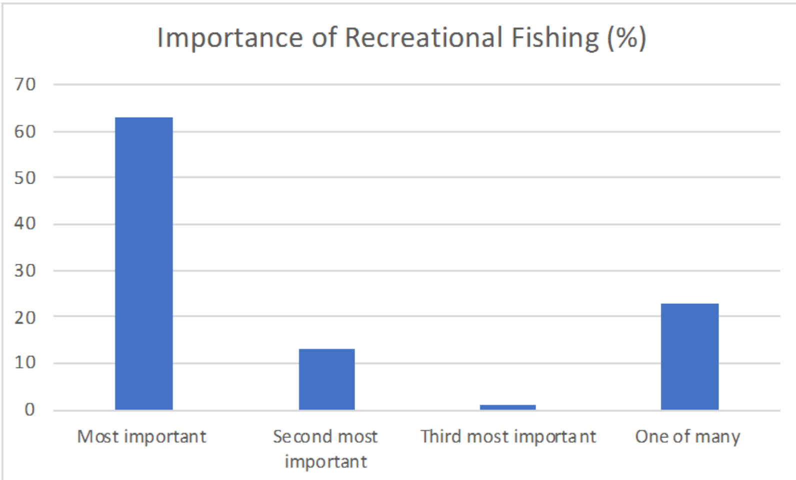


Figure 2 The importance of recreational fishing compared to other outdoor recreational activities.

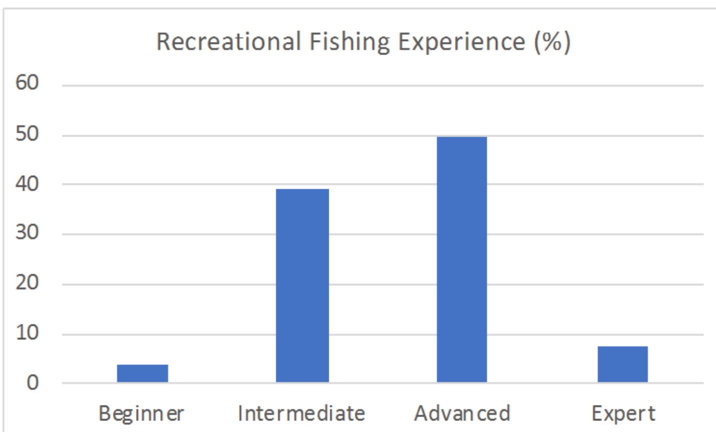


Figure 3 Level of recreational fishing experience

Dive respondent profile

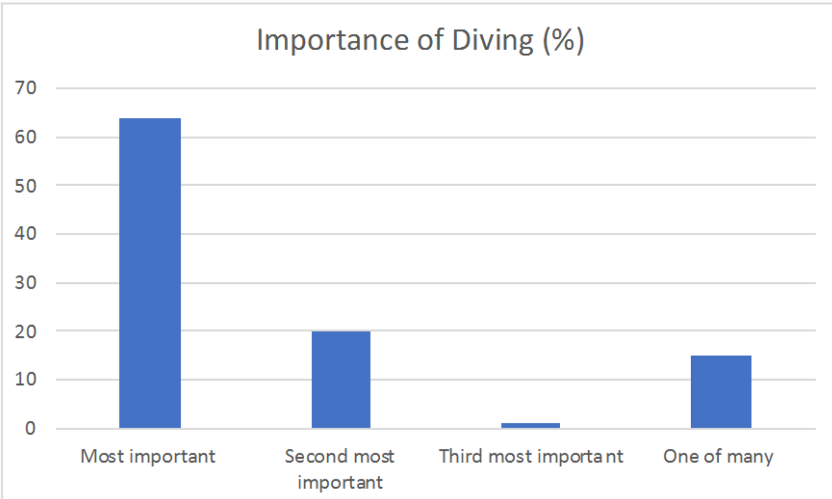


Figure 4 Importance of diving compared to other outdoor recreational activities

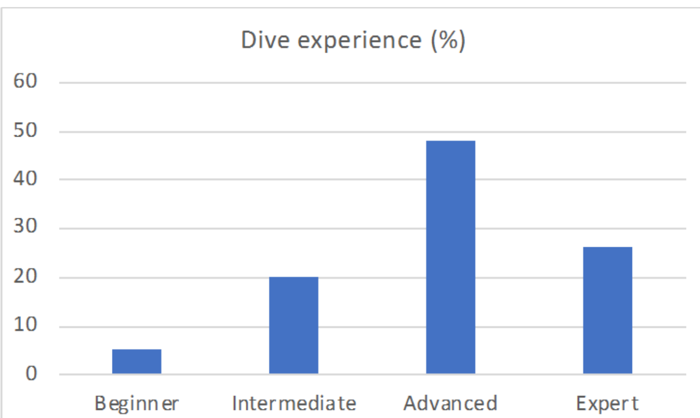


Figure 5 Level of diving experience

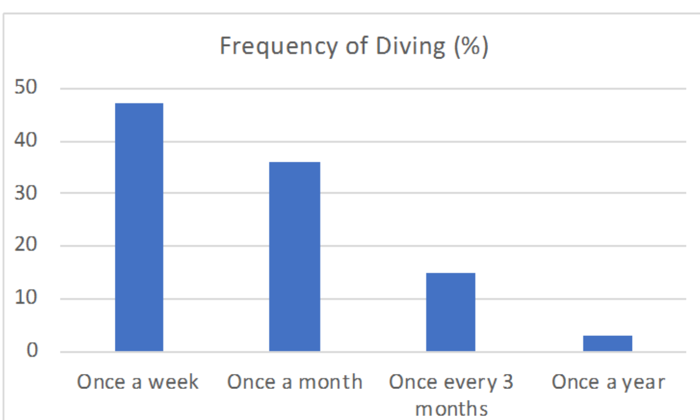


Figure 6 Frequency respondent dives in Western Australian waters

Commercial fishing respondent profile

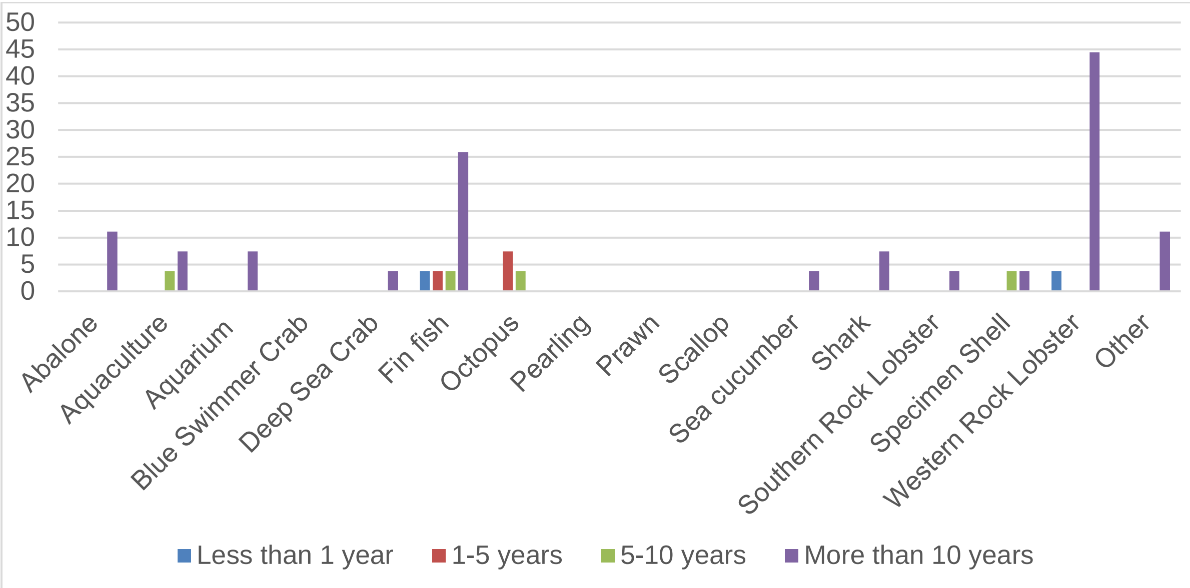


Table 6 Commercial fishing sector and number of years working in sector

		North Coast (114°50'E to NT border)	Gascoyne Coast (27°S to 114°50'E)	West Coast (115°30'E to 27°S)	South Coast (115°30'E to SA border)	Total
N	Valid	4	5	19	10	27
	%	10.5	13.1	50.0	26.3	100
	Missing	546	545	531	540	

Has the respondent fished MMS in the last 12 months?
Yes: 13 (48.1%)
No: 14 (51.8%)

Table 7 For those that had not fished an MMS in the last 12 months: Have you ever fished a man-made marine structure?

	Frequency	Percent %
Yes	2	15.4
No	11	84.6

Table 8 Why did you choose not to fish any man-made marine structures in the last financial year

	Frequency	Percent (%)
Man-made marine structures do not attract my target species	1	100.0

Final MMI survey

Start of Block: consent

Q39 **Win one of three $750 Visa Cards by participating in this man-made structure rec fishing and diving survey!**
Thank you for your interest in this survey which examines social and economic values associated with man-made aquatic structures.
Structures such as artificial reefs are playing an increasing role in shaping the recreational fishing and diving landscape. In order to plot the future direction and potential development of these structures, a better understanding is needed of the social and economic value these structures provide the community. Your participation in this survey will help develop a clearer understanding of how recreational fishers and divers are using these structures and their importance as assets for metro and regional communities.
Full details of the research are available at http://www.frdc.com.au/project/2018-053
Confidentiality and completing the survey
Taking part in a research project is voluntary. Should you change your mind at any point in the survey before submitting it, you can withdraw from the project. Any information we collect will be treated as confidential and all data collected is anonymous. The results of this research may be presented at conferences or published in professional journals. You will not be identified or be identifiable in any results that are published or presented. The survey should take no more than ten minutes to complete.   Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number CTR-10729). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au   By continuing with the survey, you agree with the following statement: "I have received information regarding this research and have had an opportunity to ask questions. I believe I understand the purpose, extent and possible risks of my involvement in this project and I voluntarily consent to take part."
The prize-draw Upon completion of the survey, you will be invited to take part in a prize draw with the chance to win one of three $750 Visa gift cards which can be used at any outlet accepting Visa payments.
1) Winners will be chosen by selecting three random entrants. This selection will be undertaken by the Chair of the Research Project Steering Committee who will not be permitted to enter the survey. This selection will be witnessed by two other members of the Steering Committee, who will also not be permitted to enter the survey.
2) Prize winners will be contacted by the researchers via email and/or phone within 48 hours of the prize draw. Verbal confirmation of age will be requested to ensure that the recipient is aged 15 or over as required by the online survey. Recipients will not be identified or identifiable publically. Only the postcode of the three winners will be published on the FRDC website.
3) Should any prize winner not be able to be contacted within one week of the draw, the above procedure will be repeated until all three prizes are claimed.

O I agree

Start of Block: Block 1 Personal

Q1.1 Please indicate your age

O 15-19

O 20-24

O 25-29

O 30-34

O 35-39

O 40-44

O 45-49

O 50-54

O 55-59

O 60-64

O 65-69

O 70-74

O 75 and over

Q1.2 Please indicate your gender

O Male

O Female

O Other / prefer not to say

Q1.3 Please type the postcode of your place of usual residence

____

Start of Block: Block 2 Fisher or diver

Q2.2 We would like to know about your recreational fishing and/or diving activities in Western Australian marine waters.

Approximately how frequently do you engage in recreational fishing in the marine waters off Western Australia? We define recreational fishing as fishing for pleasure or competition, including line, trolling, pots and spearfishing.

- O At least once a week
- O At least once a month
- O Around once every three months
- O Around once a year
- O Never

Q2.3 Approximately how frequently do you engage in diving in the marine waters off Western Australia? We define diving as a leisure and enjoyment activity that only involves looking at the marine environment. This includes snorkeling.

- O At least once a week
- O At least once a month
- O Around once every three months
- O Around once a year
- O Never

Q2.1
Would you describe yourself predominantly as a recreational fisher, a diver or neither?

- O Recreational fisher
- O Diver
- O Neither

Start of Block: Block 3 Diving practices and values

Q143 How would you compare diving to any other outdoor recreational activities you pursue?

- O Most important outdoor recreational activity
- O Second most important outdoor recreational activity
- O Third most important outdoor recreational activity
- O One of many outdoor recreational activities

Q144 Which of the following best describes you as a diver?

- O Beginner
- O Intermediate
- O Advanced
- O Expert

Skip To: End of Block If Which of the following best describes you as a diver? , Beginner Is Displayed

Q145 We would now like to know about your diving experiences around man-made marine structures. Man-made marine structures are structures in marine and coastal environments that serve a diversity of purposes, including recreation, coastal protection, transport and resource extraction. Jetties, piers, artificial reefs, shipwrecks, pipelines, and oil and gas infrastructure are all man-made marine structures.
In the past 12 months, have you undertaken any diving around the following man-made marine structures?

	Frequency		
	At least once a month	Less than once a month	Never
Busselton Jetty	O	O	O
Exmouth Navy Jetty	O	O	O
Other piers, jetties or sea walls	O	O	O
Exmouth Artificial Reef	O	O	O
Other artificial reefs	O	O	O
Onslow offshore structures	O	O	O
Pipelines	O	O	O
Shipwrecks	O	O	O

Q91 Please name the man-made marine structure you most frequently visit.

____

Q148 When thinking about the man-made marine structure you most frequently visit, how important are the following to you?

	Importance					
	Not at all important	Not particularly important	Neutral	Somewhat important	Very important	Unsure
Diving at this location	O	O	O	O	O	O
The diversity of marine species at this location	O	O	O	O	O	O
The aesthetics or visual experience of this location	O	O	O	O	O	O
Having not many other people dive at this location	O	O	O	O	O	O

Q149 Which of the following categories of marine resource is your first preference when diving?

- O Natural reef
- O Artificial reef
- O Shipwreck
- O Jetty/Pier
- O Pipelines
- O Platforms or structures

Start of Block: Block 4 Rec fishing practices and values

Q93 What form of recreational fishing do you most frequently undertake?

- O Collection by hand
- O Line fishing from a boat
- O Line fishing from the shore
- O Net fishing
- O Pot fishing
- O Spear fishing

Q2.4 How would you compare recreational fishing to any other outdoor recreational activities you pursue?

- O Most important outdoor recreational activity
- O Second most important outdoor recreational activity
- O Third most important outdoor recreational activity
- O One of many outdoor recreational activities

Q2.5 Which of the following terms best describes yourself as a recreational fisher?

- O Beginner
- O Intermediate
- O Advanced
- O Expert

Skip To: End of Block If Which of the following terms best describes yourself as a recreational fisher? , Beginner Is Displayed

Q2.6 We would now like to know about your recreational fishing experiences around man-made marine structures. Man-made marine structures are structures in marine and coastal environments that serve a diversity of purposes, including recreation, coastal protection, transport and resource extraction. Jetties, piers, artificial reefs, shipwrecks, pipelines, and oil and gas infrastructure are all man-made marine structures.
In the past 12 months, have you undertaken any recreational fishing around the following man-made marine structures?

	Frequency		
	At least once a month	Less than once a month	Never
Busselton Jetty	O	O	O
Other piers, jetties or sea walls	O	O	O
Exmouth Artificial Reef	O	O	O
Other artificial reefs	O	O	O
Onslow offshore structures	O	O	O
Pipelines	O	O	O
Shipwrecks	O	O	O

Q92 Please name the man-made marine structure you most frequently visit.

____

Q2.8 When thinking about the pleasure derived from visiting the man-made marine structure you most frequently visit, how important are the following to you?

	Importance					
	Not at all important	Not particularly important	Neutral	Somewhat important	Very important	Unsure
Fishing at this location	O	O	O	O	O	O
The amount of fish I catch at this location	O	O	O	O	O	O
The fish species I catch at this location	O	O	O	O	O	O
Having not many other people fish at this location	O	O	O	O	O	O

Q42 Which of the following categories of marine resource is your first preference when fishing recreationally?

- ○ Artificial reefs
- ○ Natural reefs
- ○ Jetties/piers
- ○ Pipelines
- ○ Shipwrecks
- ○ Platforms or structures
- ○ Other Shore-based fishing

Start of Block: Block 5 Neither

Q78 Which of the following best describes your interest in the marine environment?

- ☐ Local government
- ☐ State government
- ☐ Private sector (e.g. local business, retail or industry)
- ☐ Non-government organisation (including community groups)
- ☐ Research
- ☐ Tourism
- ☐ Other (please specify) ____

Q73 Man-made marine structures are structures in marine and coastal environments that serve a diversity of purposes, including recreation, coastal protection, transport and resource extraction. Jetties, piers, artificial reefs, shipwrecks, pipelines, and oil and gas infrastructure are all man-made marine structures.

Q79 How frequently do you visit or interact with the following man-made marine structures?

	At least once a month	Less than once a month	Never
Exmouth Navy Jetty	o	o	o
Other piers or jetties	o	o	o
Exmouth Artificial Reef	o	o	o
Other artificial reefs	o	o	o
Thevenard structures	o	o	o
Pipelines	o	o	o
Shipwrecks	o	o	o

Display This Question:

If How frequently do you visit or interact with the following man-made marine structures? [Never] (Count) < 7

Q80 Please name the man-made marine structure you most frequently visit or interact with

____

Display This Question:

If How frequently do you visit or interact with the following man-made marine structures? [Never] (Count) < 7

Q81 Thinking about this structure, how important are the following to you?

	Not at all important	Not particularly important	Neutral	Somewhat important	Very important	Unsure
The diversity of marine species at this location	O	O	O	O	O	O
The aesthetic or visual experience of this location	O	O	O	O	O	O
Opportunities for public visitation or engagement at this location	O	O	O	O	O	O
Equal access for all user groups to the site	O	O	O	O	O	O
The ecological health of this location	O	O	O	O	O	O
Your personal connection to the site	O	O	O	O	O	O
The heritage value of the site	O	O	O	O	O	O

Q82 What do you think are the social, economic or environmental benefits of man-made marine structures?

Q85 What do you think are the negative social, economic or environmental consequences of man-made marine structures?

Q72 Listed below are some uses and attributes of man-made marine structures. Please click the box that best reflects the importance of these to you.

	Importance					
	Not at all important	Not particularly important	Neutral	Somewhat important	Very important	Unsure
Fishing around man-made marine structures	O	O	O	O	O	O
Diving around man-made marine structures	O	O	O	O	O	O
Visiting man-made marine structures	O	O	O	O	O	O
Social interactions when visiting man-made marine structures	O	O	O	O	O	O
The contribution of man-made marine structures to local community identity	O	O	O	O	O	O

The contribution of man-made marine structures to ecosystem health	O	O	O	O	O	O
Unrestricted access to man-made marine structures	O	O	O	O	O	O
The educational opportunities afforded by man-made marine structures	O	O	O	O	O	O
The research opportunities afforded by man-made marine structures	O	O	O	O	O	O
The ability of man-made marine structures to divert pressure from natural systems	O	O	O	O	O	O
The contribution of man-made marine structures to local employment	O	O	O	O	O	O
The contribution of man-made marine structures to tourism	O	O	O	O	O	O

Clearly defined management responsibilities for man-made marine structures	o	o	o	o	o	o

Q86 Is there anything else that makes man-made marine structures important to you?

____

____

____

____

____

Start of Block: Block 6 All

Display This Question:

If Would you describe yourself predominantly as a recreational fisher, a diver or neither? = Recreational fisher

Or Would you describe yourself predominantly as a recreational fisher, a diver or neither? = Diver

Q89 What do you think are the social, economic or environmental benefits of man-made marine structures?

____

____

____

____

____

Display This Question:

If Would you describe yourself predominantly as a recreational fisher, a diver or neither? = Recreational fisher

Or Would you describe yourself predominantly as a recreational fisher, a diver or neither? = Diver

Q90 What do you think are the negative social, economic or environmental consequences of man-made marine structures?

____

____

____

____

____

Q167 Below are some statements regarding man-made marine structures.   Please rate your level of agreement with each statement.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Unsure
Man-made marine structures sustain and increase fish populations and other marine life over time	O	O	O	O	O	O
Man-made marine structures contribute to local tourism	O	O	O	O	O	O
Man-made marine structures provide employment opportunities in the local community	O	O	O	O	O	O
Man-made marine structures are a central point of identity for local communities	O	O	O	O	O	O
Existing management controls allow for the sustainable use of man-made marine structures	O	O	O	O	O	O
Man-made marine structures are sites of conflict between different user groups	O	O	O	O	O	O

Display This Question:

If Would you describe yourself predominantly as a recreational fisher, a diver or neither? = Recreational fisher

Or Would you describe yourself predominantly as a recreational fisher, a diver or neither? = Diver

Q168 Listed below are some uses and attributes of man-made marine structures. Please click the box that best reflects the importance of these to you.

	Importance					
	Not at all important	Not particularly important	Neutral	Somewhat important	Very important	Unsure
Fishing around man-made marine structures	O	O	O	O	O	O
Diving around man-made marine structures	O	O	O	O	O	O
The memories or souvenirs (e.g. photos) collected while fishing/diving	O	O	O	O	O	O
Unrestricted access to man-made marine structures	O	O	O	O	O	O

Independence to choose when or how I access man-made marine structures	O	O	O	O	O	O
Talking to friends or family about my fishing/diving experiences at man-made marine structures	O	O	O	O	O	O
The social connections I have made through fishing/diving at man-made marine structures	O	O	O	O	O	O
The contribution of man-made marine structures to ecosystem health	O	O	O	O	O	O
The contribution of man-made marine structures to the local economy	O	O	O	O	O	O
The contribution of man-made marine structures to local community identity	O	O	O	O	O	O

Start of Block: Block 7 Decommissioning

Q3.1 We have been asking about your experiences with man-made marine structures. Oil and gas facilities such as rigs and pipelines are one type of man-made marine structure. When these facilities come to the end of their operational life, do you believe they should be:

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

Q3.2 Do you have any other comments you would like to make?

____

____

____

____

____

Display This Question:

If Would you describe yourself predominantly as a recreational fisher, a diver or neither? = Neither

Q88 Thank you!

If you would like to be entered into the prize draw for one of three $750 Visa gift cards, please enter your email address and mobile number below. Multiple survey entries from the same individual or from respondents outside of Australia will not be eligible for the prize draw.
We will only use this information to contact you if you are selected in the prize draw.

Email address:

____

Display This Question:

If Would you describe yourself predominantly as a recreational fisher, a diver or neither? = Neither

Q40 Phone number:

____

Commercial Fishers Survey

Participant Information Form

Thank you for your interest in this survey which examines social and economic values associated with man-made marine structures.   Structures such as artificial reefs are playing an increasing role in shaping the marine landscape. In order to plot the future direction and potential development of these structures, a better understanding is needed of the social and economic value these structures provide. Your participation in this survey will help develop a clearer understanding of how commercial fishermen are using these structures and the importance of these assets.   Full details of the research are available at http://www.frdc.com.au/project/2018-053

Confidentiality and completing the survey
Taking part in a research project is voluntary. Should you change your mind at any point in the survey before submitting it, you can withdraw from the project. Any information we collect will be treated as confidential and all data collected is anonymous. The results of this research may be presented at conferences or published in professional journals.   To maintain confidentially, no data will be reported where the number of respondents is less than 5 i.e. data will be aggregated by geographical location/fishery etc to ensure that there are at least 5 respondents per group when reporting financial and all other data.   The survey should take no more than fifteen minutes to complete.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HRE2019-0465). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au

By continuing with the survey, you agree with the following statement: "I have received information regarding this research and have had an opportunity to ask questions. I believe I understand the purpose, extent and possible risks of my involvement in this project and I voluntarily consent to take part."

Block: Demographics

Q1 Please indicate your age

▼ 15-19 ... 75 and over

Q2 Please indicate your gender

▼ Male ... Other / prefer not to say

Q3 Please type the postcode of your place of usual residence

____

Block: Fisheries

Q4 Please indicate which of the following WA fisheries you currently work in and the duration of your involvement in each fishery. Select only those that apply.

	Less than 1 year	1-5 years	5-10 years	More than 10 years
Abalone	☐	☐	☐	☐
Aquaculture	☐	☐	☐	☐
Aquarium	☐	☐	☐	☐
Blue swimmer crab	☐	☐	☐	☐
Deep sea crab	☐	☐	☐	☐
Fin fish	☐	☐	☐	☐
Octopus	☐	☐	☐	☐
Pearling	☐	☐	☐	☐
Prawn	☐	☐	☐	☐
Scallop	☐	☐	☐	☐
Sea cucumber	☐	☐	☐	☐
Shark	☐	☐	☐	☐
Southern rock lobster	☐	☐	☐	☐
Specimen shell	☐	☐	☐	☐
Western rock lobster	☐	☐	☐	☐
Other (please specify)	☐	☐	☐	☐

Q5 What is your current work situation in regards to commercial fishing?

- o Full time
- o Part time
- o Casual

Q6 What is your current role?

- o Licence holder
- o Licence lessee
- o Licence holder and active fisher
- o Licence lessee and active fisher
- o Skipper (on behalf of licence holder or licence lessee)
- o Crew / deckhand

Q7 What proportion of your total personal income was derived from commercial fishing activities in the last financial year (July 1 2018 - 30 June 2019)?

- o More than 80%
- o 61-80%
- o 41-60%
- o 21-40%
- o Less than 20%

Q8 In which regions do you fish?

- ☐ North Coast (114°50′E to NT border)
- ☐ Gascoyne Coast (27°S to 114°50′E)
- ☐ West Coast (115°30′E to 27°S)
- ☐ South Coast (115°30′E to SA border)

Block: Fishing Experience

Q9 We would now like to know about your fishing experiences around man-made marine structures and purpose built FADs (fish aggregation devices). Man-made marine structures are structures in marine and coastal environments that serve a diversity of purposes, including recreation, coastal protection, transport and resource extraction. Jetties, piers, artificial reefs, shipwrecks, pipelines, and oil and gas infrastructure are all man-made marine structures.
In the last financial year (July 2018-June 2019), did you fish near any of the following man-made structures?

	At least once a week	At least once a month	Less than once a month	Never
Onslow offshore oil and gas structures	O	O	O	O
Other offshore oil and gas structures (please specify which)	O	O	O	O
Echo Yodel pipelines	O	O	O	O
Other pipelines (please specify which)	O	O	O	O
Swan or Lena shipwreck (Busselton)	O	O	O	O
Other shipwrecks (please specify which)	O	O	O	O
Exmouth artificial reef	O	O	O	O
Other artificial reefs (please specify which)	O	O	O	O
Purpose built FADs	O	O	O	O
Jetties (please specify which)	O	O	O	O

Display This Question:

If We would now like to know about your fishing experiences around man-made marine structures and pu... [At least once a week] (Count) >= 1

Or We would now like to know about your fishing experiences around man-made marine structures and pu... [At least once a month] (Count) >= 1

Or We would now like to know about your fishing experiences around man-made marine structures and pu... [Less than once a month] (Count) >= 1

Q10 Please name the man-made marine structure you most frequently fished during the 2018-19 financial year.

____

Display This Question:

If We would now like to know about your fishing experiences around man-made marine structures and pu... [At least once a week] (Count) >= 1

Or We would now like to know about your fishing experiences around man-made marine structures and pu... [At least once a month] (Count) >= 1

Or We would now like to know about your fishing experiences around man-made marine structures and pu... [Less than once a month] (Count) >= 1

Q11 When thinking about the man-made marine structure you most frequently fish, how important are the following to you?

	Importance					
	Not at all important	Not particularly important	Neutral	Somewhat important	Very important	Unsure
Unregulated access to the site (e.g. open access for all)	O	O	O	O	O	O
Ease of access (eg en route to other fishing sites)	O	O	O	O	O	O
The quantity of target species present	O	O	O	O	O	O
Limited / no conflict with other users	O	O	O	O	O	O
Limited competition for access to site	O	O	O	O	O	O
Your familiarity with fishing this site	O	O	O	O	O	O

Display This Question:

If We would now like to know about your fishing experiences around man-made marine structures and pu... [At least once a week] (Count) >= 1

Or We would now like to know about your fishing experiences around man-made marine structures and pu... [At least once a month] (Count) >= 1

Or We would now like to know about your fishing experiences around man-made marine structures and pu... [Less than once a month] (Count) >= 1

Q12 Is there anything else that makes this man-made marine structure important to you?

____

Block: Use of MMS

Display This Question:

If We would now like to know about your fishing experiences around man-made marine structures and pu... != At least once a week

And We would now like to know about your fishing experiences around man-made marine structures and pu... != At least once a month

And We would now like to know about your fishing experiences around man-made marine structures and pu... != Less than once a month

Q13 Have you ever fished a man-made marine structure?

o Yes

o No

Display This Question:

If Have you ever fished a man-made marine structure? = Yes

Q14 What type of man-made marine structure did you most recently fish and how long ago?

	Between 12-18 months ago	Between 18-24 months ago	Between 2-3 years ago	More than 3 years ago
Offshore oil and gas structures	o	o	o	o
Oil and gas pipelines	o	o	o	o
Shipwrecks	o	o	o	o
Artificial reefs	o	o	o	o
Purpose built FADs	o	o	o	o
Jetties	o	o	o	o

Display This Question:

If Have you ever fished a man-made marine structure? = Yes

Q15 Why did you choose not to fish any man-made marine structures in the last financial year (2018/19)? Please tick all that apply.

- o Man-made marine structures do not attract my target species
- o My target species is not available in sufficient volumes around man-made marine structures
- o Man-made marine structures are further away than natural sites
- o Natural fishing sites meet my needs
- o I am not familiar with fishing around man-made marine structures
- o I want to avoid conflict with the recreational sector
- o Other (please specify) ____

Display This Question:

If Have you ever fished a man-made marine structure? = No

Q16 Why have you never fished man-made marine structures? Please tick all that apply.

- o Man-made marine structures do not attract my target species
- o My target species is not available in sufficient volumes around man-made marine structures
- o Man-made marine structures are further away than natural sites
- o Natural fishing sites meet my needs
- o I am not familiar with fishing around man-made marine structures
- o I want to avoid conflict with the recreational sector
- o Other (please specify) ____

Display This Question:

If Have you ever fished a man-made marine structure? = Yes

Or Have you ever fished a man-made marine structure? = No

Q17 Will you fish man-made marine structures in the future? Please give a reason for your answer.

____

Display This Question:

If Have you ever fished a man-made marine structure? = Yes

Or Have you ever fished a man-made marine structure? = No

Q18 What would make man-made marine structures a more viable location for your fishing activities?

____

Block: Perspectives

Display This Question:

If Have you ever fished a man-made marine structure? = Yes

Or Have you ever fished a man-made marine structure? = No

Q19 While you have not, or did not, in the last financial year (2018/19), fish man-made marine structures, we would like your perspectives on their use and value in Western Australia in general.

Display This Question:

If We would now like to know about your fishing experiences around man-made marine structures and pu... [At least once a week] (Count) > 1

Or We would now like to know about your fishing experiences around man-made marine structures and pu... [At least once a month] (Count) >= 1

Or We would now like to know about your fishing experiences around man-made marine structures and pu... [Less than once a month] (Count) >= 1

Q20 We would now like to ask you some questions about man-made marine structures in Western Australia in general.

Q21 What do you think are the benefits of man-made marine structures in Western Australia?

____

Q22 What do you think are the negative consequences of man-made marine structures in Western Australia?

____

Q23 Thinking about man-made marine structures in Western Australia, please rate your level of agreement with the following statements.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Unsure
Man-made marine structures contribute to the productivity of my target species	O	O	O	O	O	O
Man-made marine structures improve sustainability of fish resources	O	O	O	O	O	O
Man-made marine structures provide opportunities to learn more about the marine environment	O	O	O	O	O	O
Man-made marine structures provide employment opportunities in the local community	O	O	O	O	O	O
Man-made marine structures are a central point of identity for local communities	O	O	O	O	O	O
Man-made marine structures contribute to local tourism	O	O	O	O	O	O
Man-made marine structures divert pressure from current natural commercial fishing sites	O	O	O	O	O	O

Existing management controls (ie open access for all) allow for the sustainable use of man-made marine structures	o	o	o	o	o	o
Man-made marine structures are sites of conflict between different user groups (such as recreational fishermen, commercial fishermen and/or recreational divers)	o	o	o	o	o	o
Man-made marine structures negatively affect my commercial fishing activities (e.g. by limiting access to fishing locations, damage to gear etc)	o	o	o	o	o	o

Block: Decommissioning

Q24 We have been asking about your experiences with man-made marine structures. Oil and gas facilities such as rigs and pipelines are one type of man-made marine structure. When these facilities come to the end of their operational life, do you believe they should be:

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

Block: Economic Value

Display This Question:

If What is your current role? = Licence holder and active fisher

Or What is your current role? = Licence holder

Q25 We would now like to ask a final few questions about the economic value of your catch.

Please note: To maintain confidentially, no data will be reported where the number of respondents is less than 5 i.e. data will be aggregated by geographical location/fishery to ensure that there are at least 5 respondents per group when reporting financial and all other data.

Q26 What is the total value of your catch in the last financial year (July 2018 - June 2019), in thousands of dollars?

____

Display This Question:

If What is your current role? = Licence lessee and active fisher

Or What is your current role? = Skipper (on behalf of licence holder or licence lessee)

Or What is your current role? = Licence lessee

We would now like to ask a final few questions about the economic value of your catch.

Please note: To maintain confidentially, no data will be reported where the number of respondents is less than 5 i.e. data will be aggregated by geographical location/fishery to ensure that there are at least 5 respondents per group when reporting financial and all other data.

Q27 What is the total value of the catch from the commercial fishing licence(s) you owned /leased or skippered in the last financial year (July 2018-June 2019), in thousands of dollars?

____

Q28 Can you estimate what proportion of that has come from fishing man-made marine structures and/or FADs?

- o zero
- o 1-25%
- o 26-50%
- o 51-75%
- o 76-100%

Display This Question:

If Can you estimate what proportion of that has come from fishing man-made marine structures and/or... != zero

Q29 If those man-made marine structures or FADs were not available for some reason, and you had to re-allocate effort, what would be the percentage reduction in the total value of catch?

	0 10 20 30 40 50 60 70 80 90 100
Reduction in value of catch without marine man-made structures	

Block: Comments

Q30 Do you have any other comments you would like to make?

____

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

Appendix 4 The potential economic value associated with the development of artificial reefs in Western Australia

Dr Paul McLeod, Dr Johanna Zimmerhackel & Dr Michael Burton

This appendix is part of the final report for:

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

Euan S. Harvey, Fran Ackermann, Michael Burton, Julian Clifton, Carmen Elrick-Barr, Johanna Zimmerhackel, Georgina Hill, Stephen J Newman, Jenny Shaw, Mark Pagano, Paul McLeod, Dianne McLean, Julian Partridge

24th August 2021

The Potential Economic Value Associated with the Development of Artificial Reefs in Western Australia

Prepared for the FRDC Project: Enhancing the Understanding of the Value Provided to Fisheries by Man-Made Aquatic Structures

Report Prepared By:

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Contents

1 Executive summary

This report provides a framework for estimating the benefits that may arise as a result of developing artificial reefs. Those values can be broadly categorised as direct economic values that arise from expenditures by users of the reefs, the 'surplus' value that arises from the enjoyment of the activities by those engaged in the activities, and the potential 'existence' values that may be generated for those who do not use the reef, but who value the improved ecological outcomes never the less.

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

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

Due to the lack of primary data that would allow a more bespoke evaluation, we generate estimates of the values using a 'benefit transfer' approach. This involves taking values from the literature and applying them to this context. Moreover, at this stage we consider only the values that arise from recreational fishing (and for the Thevenard structures recreational diving).

Results of this report suggest that the Thevenard oil and gas infrastructure off Onslow 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 per year and the additional consumer surplus between \$10,087 and \$189,872 per year. However, these values only assume one artificial reef whereas the oil and gas structures around Thevenard could be used to create various artificial reefs which would generate higher economic benefits.

We have also qualitatively identified economic benefits for recreational dive tourism, charter boat operators and commercial fisheries, including aquarium fish harvest. At this stage, the available information does not allow a meaningful estimate of these values. However, there is clear potential for the oil and gas structures to enhance the viability of dive tourism, charter boat operators and commercial fishing in the Onslow region.

We estimate that the EIAR will increase the number of fishing trips to the Exmouth area at least by 227 and at the most by 1521, depending on whether the new site primarily leads to substitution among other sites or leads to new trips. The increase in expenditure in the region that arises from this could range from \$160,000 to \$1,051,000. The associated increase in the consumer surplus enjoyed by recreational fishers varies from \$114,500 to \$267,000. 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 willingness to pay by the general public for enhanced ecological outcomes.

However, 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.

This also highlights the importance to recognise that all activities have to be managed within an appropriate management plan.

2 Introduction

The value of reefs for recreational fishing, diving and tourism is well documented. However, the role of natural reefs in generating recreational value is limited by their capacity and location. Capacity limits are typically based on the requirements to manage the reef environment for long term sustainability of the fish populations and the broader ecology. In some cases, even before ecological capacity is reached congestion will diminish the value of accessing a location and limit demand. We note that 'congestion' may occur in an economic sense independent of any physical constraint on access e.g. if congestion is denoted as a loss in value due to the presence of others then in some contexts 'congestion' may be present at very low densities of use (i.e. for those who are seeking a wilderness experience), or a desire to engage with the resource without the visual presence of any (or few) others. Congestion can arise for both diving and fishing for those sectors that are unregulated. For commercial dive tourism, charter and commercial fishing, activities are subject to various licence and management arrangements that affect the number of participants. For recreational boating activity (fishing, diving, pleasure boating) the number of participants is generally not regulated, although catch would be regulated by bag limits.

Artificial reefs and related structures aim to emulate the role and value of natural reefs by creating similar environments. These structures are well established as a mechanism to improve the marine environment through (i) the attraction of species from an existing stock in the surrounding areas, (ii) an increase in the number and density of species due to enhanced habitat and/or protection from predators, and (iii) the increase of diversity by developing new species in certain areas. As a result, artificial reefs improve the ecology, supplementing natural reef systems. They also improve the recreational value of the marine environment in the area in which the structure is located. This is achieved by improving the quality of the recreational experience for those who currently access the region and by encouraging increased participation in the area by those who currently do not access the area for fishing, diving and other related marine activities.

By adding to the stock of reef environments in an area, these structures allow for increased participation in reef-based tourism, fishing and diving while at the same time relieving pressure on other (natural) reef environments. As well as reducing pressure on the natural environment, this expanded capacity reduces the congestion costs associated with accessing natural reefs in high demand locations. Moreover, because they can be positioned in preferred locations, this enhancement of fishing, diving and tourism outcomes can potentially be delivered at lower cost and with greater safety for users.

The increased stock of reef environments also offer potential benefits for commercial fishing, including aquarium fish. In particular, enhanced value for commercial fishers is possible because species already well established commercially have been identified around existing structures. As documented in the main body of the report several of the species identified are commercially as valuable as the iconic Pink Snapper. The biomass in the area is currently not fished. This value will depend on how the area and biomass are factored into future harvest strategies. If this biomass is deemed to be part of the wider currently fished biomass such that an increase in catch may not be permitted, the expanded area may still result in improved fishing efficiency due to higher accessibility and catchability. If this biomass is deemed to be independent of the biomass currently fished outside of the area, it represents a potential expansion of the commercial catch. If the oil and gas infrastructure cause spill-over into other areas open to commercial fisheries, the full removal of the structures might cause loss of value to these fisheries.

2.1 Aim of the report

Firstly, this report describes the total economic value framework and applies it to identify the economic values of artificial reefs through a review of the scientific literature. Secondly, this report presents an approach of evaluating the economic value of artificial structures in the marine environment. Thirdly, this report aims is provide indications of the potential economic value that artificial reef(s) made from oil and gas infrastructure in the Onslow area could generate and the economic value that the EIAR provides for recreational fishing and other recreation activities.

The EIAR has only recently been established, so data on its economic impact and value is limited. At the moment, there is no structure in the Onslow area and the exact location and form of any future structure is yet to be decided. However, by using these examples as the basis for the analysis, we ground our empirical analysis in particular case studies, while illustrating the general principles that need to be applied for the evaluation of any such structure.

3 The economic value of artificial reefs

Economic values associated with the natural environment are usually described in various value types which together add up to the total economic value (TEV). This TEV framework has been widely applied to measure the change in values when interventions impact on the natural environment, such as the development of artificial reefs in the marine environment. Table 1 shows the benefits of artificial reefs within the TEV framework. **Direct use values** include consumptive and non-consumptive use values, with consumptive use values covering the values that result from extractive uses such as commercial and recreational fishing around artificial reefs. **Non-consumptive use values** are derived from usages that do not diminish the amount of the resource. For example, artificial reefs provide non-consumptive use values through recreational activities such as diving and surfing. **Indirect use values** are benefits that artificial reefs generate in the marine environment which affect other economic activities. These benefits include various reefing effects such as habitat enhancement, increased fish production and coastal protection. Different from the direct and indirect use values which are commercial in nature, **non-use values** result from the satisfaction that people derive from goods or services, without them necessarily having to interact directly with the resource. This can be for example peoples' value for knowing that a natural resource has been conserved or improved without necessarily using it. In the context of marine artificial structures, non-use values include, the knowledge that artificial reefs have increased species diversity (existence values) or conserved a species for future generations or other people (bequest/altruistic values).

*Table 1: Values attributed to artificial reef development**

Total economic value		
Direct use values	**Indirect use values**	**Non-use values**
Benefits arising from the immediate use of an artificial structure in the form of outputs that can be consumed or enjoyed directly.	Benefits that an artificial structure provides to support other economic activities, or positive externalities that affect other users of the marine environment.	Benefits from knowing that a marine asset has been conserved (existence and bequest/altruistic values) or may be available for use at a later date (option value).
Examples: - Extractive uses (e.g. commercial and recreational fishing, offshore aquaculture) - Non-extractive uses (e.g. diving and surfing tourism)	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 - Vicarious consumption	Examples: - Knowledge that reef-based protection has increased marine biodiversity - Knowledge that a unique habitat is conserved intact for future generations

* *Adapted from Whitmarsh et al. 2008*

3.1 Literature review: The economic value of marine infrastructure

Studies on the economic value of marine infrastructure in Australia is scarce. Therefore, this report presents evidence of the economic value of these structures using examples from international literature. A systematic literature research found 33 studies that quantified the economic value that marine man-made structures provide to stakeholders such as divers (19), recreational fishers (12), commercial fisheries (8), the general public (3) and other user groups (6). Since the first study on the economic value of a marine artificial structure was published in 1973 by Buchanan, the number of publications on this topic has steadily increased and the issue has started to gain considerably more attention in the last 2 decades (Figure 1). While the literature indicated economic values from artificial reefs all over the world, nearly half of these studies (15) were conducted in the USA and much less in other parts of the world. Various structures were valuated with shipwrecks being the most common (16), followed by concrete structures (8) and oil and gas platforms (5). A total of 28 studies quantified direct use values and 17 non-use values and to our knowledge no study has estimated indirect use values. All economic valuation studies are summarized in Appendix A.

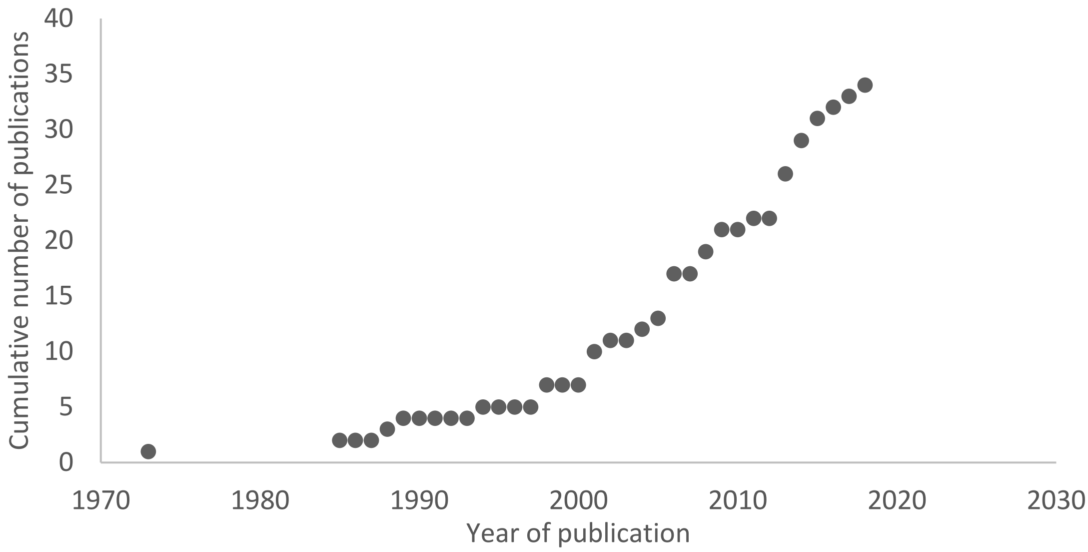

Figure 1: Cumulative number of economic valuation studies of artificial reefs.

3.1.1 Direct use values

Artificial reefs have been found to generate direct use values in terms of business revenues from commercial fishing (Vivekanandan et al., 2006, Brock, 1994, Islam et al., 2014), recreational fishing (Buchanan, 1973, Kolian et al., 2018, Milon, 1989), scuba diving (Westerberg et al., 2013, Chen et al., 2013, Leeworthy et al., 2006) and of other recreational and tourism activities including snorkelling, surfing, and boat tours (Pendleton, 2005, Westerberg et al., 2013). 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. Moreover, 16% of recreational fishers in the area stated that they would not return to the area if the artificial reef was not there. Hence, the revenues of these fishers would be lost without that reef. Also, a shipwreck in Florida, USA increased total recreational expenditures from snorkelers, divers and boating by USD2.7 million (Leeworthy et al., 2006).

Many valuation studies on marine artificial structures include economic impact assessment. Economic impact assessments quantify the increased economic activity that e.g. the deployment of an artificial reef brings to the region. This is typically measured as the number of jobs and the income the artificial reef is generating. For example, Hiett and Milon (2002) found the recreational activity (such as fishing and diving) associated with oil and gas facilities in the Gulf of Mexico not only generated USD324.6 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 oil and gas structures to be very important to their businesses. Similarly, Johns et al. (2001) estimated that Florida's artificial reef programs provide 34,900 jobs and are generating USD2.8 billion of income annually.

In addition to revenues from recreational activities, artificial reefs also have been found to provide economic benefits to commercial fisheries. Examples of this are the oil and gas platforms in the Gulf of Mexico which provide habitat for snapper populations and today, a significant part of the commercial harvest originates from petroleum platforms (Bull and Love, 2019). Most economic studies of artificial reefs have compared the revenues of commercial fisheries on artificial and natural reefs. Kasim et al (2013) found that the revenues of commercial fishers in India were over twice as high on artificial reefs compared to adjacent natural reefs and Vivenkandan et al. (2006)

estimated the income from hook and line fishing on artificial reefs to be 36% higher than on non-artificial reef sites. Similarly, Whitmarsh et al. (2008) found the revenues from an artisanal fishery on an artificial reef off the Algarve in Portugal to be substantially higher than on control sites. However, the monthly fishing income from artisanal fishers on an artificial reef in Malaysia was lower than on adjacent natural reefs (Islam et al., 2014). Also, Crabbe and McClanahan (2006) observed that not all commercial fisheries benefited from shipwrecks in Kenya.

Another potential source of economic value from offshore oil and gas structures is the harvest of ornamental fish. Kolian et al. (2018) estimated that in the Gulf of Mexico, a sustainable harvest of aquarium fish could yield approximately USD1.4 million per platform per year. Moreover, they point out that there is an unknown value in novel pharmaceutical and/or nutritional products that could be sourced from marine invertebrates that grow on oil and gas platforms.

Recreational fishers can increase their satisfaction through the increase the catchability and/or the catch rate during their fishing trips. McGurrin and Fedler (1989) compared the perception of fishers that fish on and off an oil and gas platform and found that platform user felt that both the size and types of fish that could be caught were better than off the structure. Consequently, fishers that fished on oil and gas platforms were willing to pay more (USD19.38) for another artificial reef site than non-platform fishers (USD10.00).

Artificial reefs not only directly enhance habitat but also 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 harm natural reefs. Hannak et al. (2011) did a willingness to pay study and found that especially the less experienced snorkelers (who are more likely to damage the reefs) were willing to pay for the snorkel trail, education about reef ecology, threats to the reef and skill training to protect natural reefs.

Finally, the controlled position of artificial reefs allow for safer conditions than on some natural sites. Christie (2009) found that all members of a community in Wales held significant values for a multipurpose reef which would provide (among other attributes) safer swimming opportunities. Likewise, Taiwan residents were willing to pay WTP of about USD13 per recreational fishing and diving trip for access to an artificial reef zone that provides safer conditions than surrounding areas (Chen et al. 2013).

3.1.2 Indirect use values

While the described reefing effects (see Table 1) are widely acknowledged in the literature, to our knowledge no studies have sought to quantify the economic indirect use values associated with marine artificial structures. The reason for this is probably that different value types can overlap and the complexity involved in such valuations. Firstly indirect values, almost by definition, involve potentially complex environmental linkages and economic linkages and typically occur outside of the direct area of interest. For example, effort diversion could occur from a range of substitute sites which could conceivably be some way from the area of interest. Effort diversion could also be time related in that an activity that is a direct use activity of the reef of interest this period may simply defer use of the alternative location to another year.

Secondly, potentially significant indirect benefits have the characteristic of a public good. For example a diver or fisher photographs their experience on the reef. Their experience is a direct use that can meaningfully be valued. If they post a video of their experience on YouTube, many users can derive value from watching without visiting the area (vicarious consumption) and they do not compete with each other to watch.

If indirect values are pursued, a question of double counting also arises. As an example, consider habitat enhancement, leading to improved stock and catch rate. This will be measured by the direct use value of the associated catch and fishing experience. Similarly, the direct use value for diving reflects the habitat enhancement. This can be added to the fishing value to get an aggregate value for the direct uses.

However, if a separate estimate was made for the habitat enhancement per se, without reference to the fishing and diving values, it would be double counting. Only a residual value for the habitat that is not accounted for by the direct use values could legitimately be included.

Similarly, if a stated preference study is conducted to derive estimates of non-use values from a general population sample, it is important to recognise that those who gain *use values* from the resource will include these values in their stated value. Thus aggregating both total revealed and stated preference values will result in an overstatement of value.

These issues are not insurmountable, but require careful accounting frameworks that identify which values are being captured by which techniques, and to ensure that overlaps are adjusted for. For example, if a stated preference study is undertaken for general population existence values, but a travel cost recreational fisher survey is employed for fisher use values (because of its greater sensitivity to spatial distributions) then potentially one is double counting. But if in the stated preference study preferences by demographics are disaggregated by stakeholder, then it would be possible to infer fishers' existence values from the general population, and their use values from the travel cost method.

3.1.3 Non-use values

Non-use values result from peoples' satisfaction which a natural resource provides that is not traded in a market. This satisfaction can have various sources. For example, as described above, artificial structures in the ocean have the ability to enhance marine habitat and therefore improve the biodiversity and/or abundance of marine life on and around them. Although there is no process by which these values can be captured by any party techniques exist that quantify them in monetary form. Hence, people who value these natural benefits can have a "willingness to pay" for maintaining artificial structures. For example, Börger et al. (2015) estimated the willingness to pay of residents in Ireland for an increase in biodiversity on an offshore windfarm off the coast of Ireland. They found that people were willing to pay GBP7.25 and GBP14.83 per person for an increase of ten and 30 species settling on the windfarm, respectively. It is reasonable to expect that residents of Western Australia would have some positive willingness to improve biodiversity on the North West shelf, although this would need to be tested with appropriate surveys.

The willingness to pay to protect artificial reefs and natural reefs can vary. In southeast Florida, visitors and residents are willing to pay more than double (USD229.3 million/year) as much to protect natural reefs than artificial reefs (USD85.1 million/year) (Johns et al., 2003). On the other hand, Huth et al. (2015) found that dive tourists in Florida had higher willingness to pay for a dive trip to a shipwreck (USD368) than to natural reefs (USD300).

3.1.4 Attraction vs. production

It becomes evident from the literature that the economic values associated with artificial structures largely depend on their capacity to enhance the marine environment. While it is widely acknowledged that the presence of artificial structures have increased fish populations associated with them, there is a continuing discussion about whether these structures merely attract and aggregate fish or also increase the production of existing fish stocks (Bull and Love, 2019). Researchers that found an aggregation effect on artificial reefs are concerned that artificial reefs increase the vulnerability of fish populations to fishing and therefore contribute to overfishing (Pickering and Whitmarsh, 1997). However, various species have been found to use artificial structures as nursery grounds and therefore increase the production of these species (Claisse et al., 2014). This can not only increase fish stocks on the structures but also supply recruits to other areas via spill-over effects. Also, there is evidence that fish are recruiting to artificial structures as juveniles, suggesting that the structures are not only attracting adults from surrounding habitat (Fowler and Booth 2012). The degree of attraction and production effects in each artificial reef varies depending on a variety of factors including the proximity to other reefs (Bohnsack 1989, Strelcheck et al. 2005). This most likely has effects on the behaviour of reef users and consequently the economic benefits that these structures provide.

It is worth noting that the impacts of aggregation v production are likely to have different impacts on the different values. For example, aggregation does not cause an increment in the underlying ecology, and hence has no impact on non-use values. (However, it may still create benefits for use values if it reduces fishing trip related expenditures. Fisheries management such as harvest restrictions, temporal closures or the designation of some AR as no-take areas could ensure that artificial reefs meet their targets and maintain ecologically and economically sustainable fisheries.

3.2 Literature review: The value of recreational fishing in Australia

A primary focus of the discussion relating to artificial structures in the North West has been their value for fishing. It is therefore useful to begin with a short review of studies relating to the value of recreational fishing in Australia and in Western Australia in particular.

3.2.1 Expenditure studies of recreational fishing in Australia and Western Australia

Most value studies have focused on the economic impact of recreational fishing expenditures. The most recent detailed expenditure survey for recreational fishing is one for Victoria in 2008/09 (Ernst & Young 2009a). This was updated in 2013/14 (Ernst & Young 2015). The 2008/09 study reported the following key findings.

- An estimated 721,000 Victorians participated in recreational fishing. Victoria's population in June 2009 was 5.44 million. Recreational fishers were 13 percent of this population and 19 percent of the adult population.
- The number of fishing trips taken in Victoria is estimated at an average of 12 per year per fisher, making total fishing trips 8.7 million;
- Average expenditure per trip per fisher is estimated to be $250 inclusive of variable costs (such as accommodation, bait, fuel etc) and fixed costs (such as equipment and capital);
- Aggregate direct expenditure was valued at $2.3 billion in 2008-09.
- Aggregate direct expenditure is estimated to increase to $2.9 billion in 2028-29.

The later study (Ernst & Young 2015) reported the following.

- Lower average trips per fisher of 7.3 although the participation rate has stayed about the same at 18 percent of the adult population.
- Average per trip expenditure by fishers of $326 excluding boat purchase.
- Aggregate direct expenditure was valued at $2.6 billion in 2008-09.
- Aggregate direct expenditure is estimated to increase to $3.3 billion in 2028-29;

A 2012/13 survey of recreational fishers in Tasmania (Lyle et al. 2014) found the following.

- 98,000 Tasmanian residents aged 5 years or older fished at least once in Tasmania, representing an overall participation rate of 22%.
- Recreational fishers accounted for about 507,000 person days of effort, with an average of 5.5 days per fisher.
- Direct expenditure is estimated to $93 million on goods and services relevant to fishing, $1008 per fisher or $183 per day.

In 2012 a NSW survey of recreational fishers (McIlgorm & Pepperell 2014) found the following.

- 905,048 anglers fished in NSW with 773,000 adults over 18 years of age. The NSW population in June 2012 was 7.29 million. Recreational fishers were 12.4 percent of this population and 14 percent of the adult population
- Average trips per year were 10.7 combined saltwater and freshwater. Average days fished per year were 14.6.
- Average expenditure per angler of $225.24 per trip. - $154.05 on fishing trip related items plus $71.20 was spent on tackle and boat fuel per trip.
- Annual fishing related boat expenditure averaged $768.15 per angler.
- Aggregate expenditure was estimated at $1.626bn per year, $1.439bn from NSW residents alone.

An early study economic impact study of recreational fishing in Western Australia was completed in 1991 by Lindner and McLeod. Two surveys, one by telephone interviews of 401 recreational fishers, and another via a self-enumeration questionnaire of a non-random self-selecting sample were conducted to determine how much recreational fishers spend during a year on goods and services on activities related to fishing. Total annual expenditure associated with recreational fishing was estimated to lie within the range from $200 million to $415 million.

The original Lindner and McLeod study was updated in 2018 and estimated aggregate expenditures to be:

- $1,859,607,819 for trip related expenditure (incl. land travel to site of fishing platform and accommodation on overnight trips)
- $159,890,879 for gear related expenditure
  $389,029,065 for boat related expenditure (incl. boat hire and charter fees)
  Aggregate expenditure was $2.41 billion, or $1.80 billion if costs for Food & Refreshments are excluded.

For more details on this report, see Appendix B.

3.2.2 Willingness to pay studies of the value of recreational fishing

Studies directly relevant to Western Australia are limited. Use of revealed preference techniques (van Bueren 1999; Raguragavan et al. 2013) has allowed imputation of economic value for catch and site, but sites are defined at a very large geographical level. Van Bueren estimated values for share based fishing for five categories of fish (namely prize fish, reef fish, key sports fish, butter fish and table fish) and for 13 recreational fishing sites on the southwest coast. He found that angler benefits range from A$13.00 to $39.00 per day of fishing. Raguragavan et al. used essentially the same methodology, but with an expanded, albeit dated data set drawn from the 2000/2001 National Survey of Recreational Fishing. Their published economic welfare estimates for a 100 per cent catch rate increase ($/trip) for the five categories of fish ranged from $14.88 for table fish to $31.41 for prize fish. They also estimated the access value for forty-eight West Australian fishing sites, defined as the welfare loss suffered by an angler if a site became unavailable. Averaged across all sites, welfare losses from a site closure amount to $3.81 per trip per angler.

4 Methodology

4.1 Study sites

4.1.1 Thevenard Island oil and gas infrastructure

Thevenard Island is part of the Mackerel Islands group off Onslow in the North Coast bioregion, approximately 25 km northwest of Onslow and 70 km southwest of Barrow Island. Offshore oil and gas infrastructure around Thevenard Island includes three platforms in the depth of 12-18 m and six monopods in 9-16 m of water (Figure 2) as well as pipelines and other infrastructure. Production from the offshore fields ceased in January 2014 and structures are due to be decommissioned imminently. These structures could be available for artificial reef projects.

The exact form, location and quantity of potential artificial reef(s) is yet to be decided. The total area of the nine platforms is 815 m^2 (Harvey et al. 2020b). There is also an exclusion zone of 500 m around the structures to which the public currently has no access. Therefore, as of now, there are no activities such as commercial and recreational fishing nor other tourism tours associated with the platforms.

The Mackerel Islands are a group of ten islands that are a popular destination for recreational fishers and other water-related activities such as snorkelling and scuba diving. There are accommodation options on two of the islands (Mackerel Island Resort on Thevenard Island and the Direction Island Beach Shack on Direction Island).

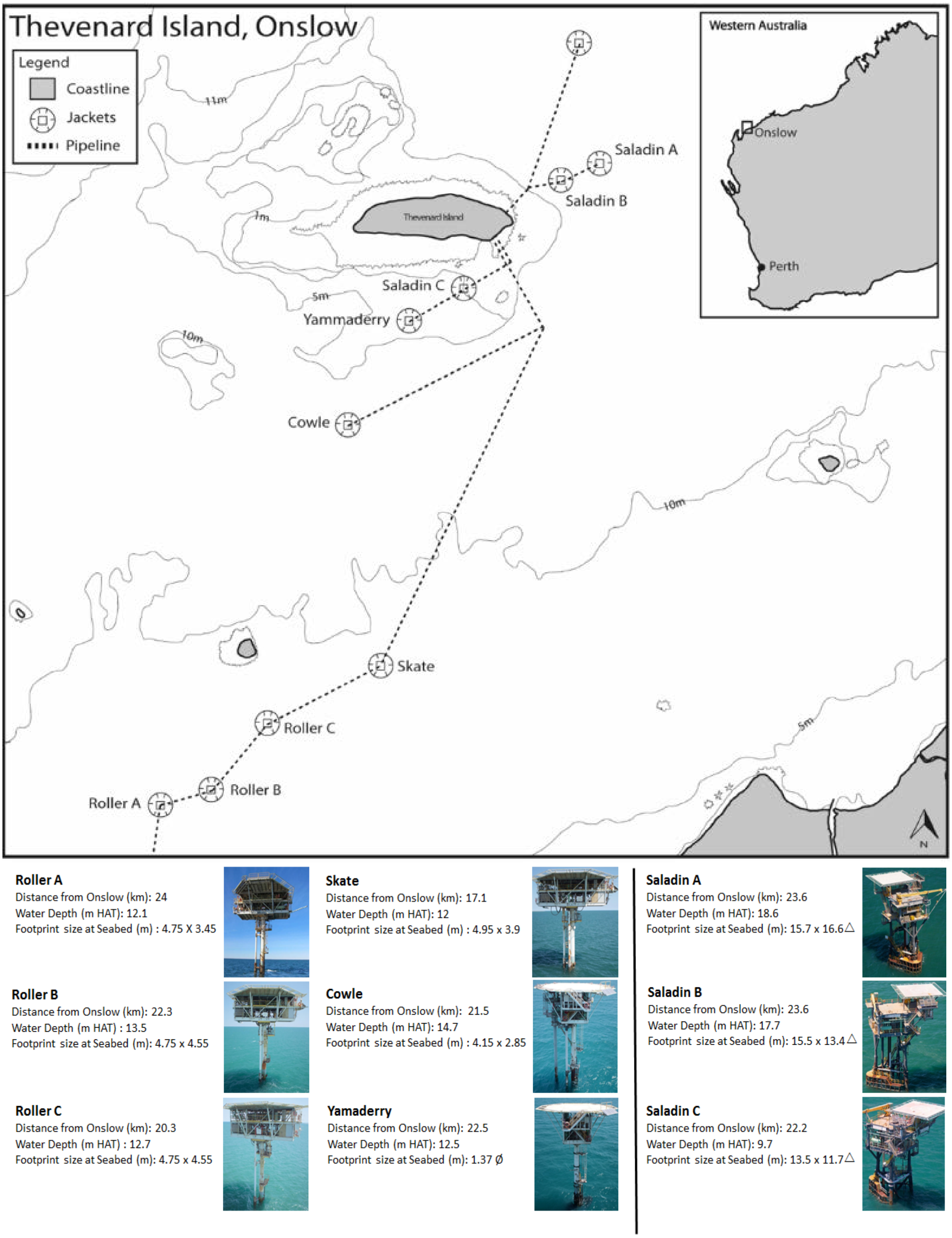

Figure 2: Location and characteristics of Thevenard oil and gas infrastructure. Source: Harvey et al. 2020b.

4.1.2 The Exmouth Integrated Artificial Reef

The EIAR was deployed in July 2018 with the purpose to enhance habitat to benefit the environment as well as to provide an accessible and safe recreational fishing site in Exmouth, Western Australia. The Exmouth location is within the Geraldton Coast bioregion.

In Exmouth, recreational fishing on the Ningaloo reef is limited due to rough weather conditions. Hence, the EIAR was positioned well accessible and inside the Exmouth Gulf where weather conditions are more stable. The EIAR comprises 49 concrete modules (1 to 10 m) and six steel tanks (Fish Towers) which make up 27,000 cubic meters of habitat on two acres of ocean floor in 17 m depth (Figure 3).

The funding for the reef was $1 million through the Recreational Fishing Industry Fund (RFIF), BHP and NERA. Other groups involved with the project across funding and research include Subcon, Curtin University, BHP, and Recfishwest.

There is a monitoring BRUVS citizen science project (Reef Vision) in place which has collected data for analysis at Curtin University. The monitoring project is dealing with the early stages of reef development but has to date recorded 40 species on and around the reef. Six months after deployment the variety of species recorded include a range of species valued by recreational fishers including:

- Pelagic species: golden trevally, school mackerel, tuna, trevally, potentially sailfish
- Demersal species: red emperor spangles emperor, rankin cod, coral trout, bluebone

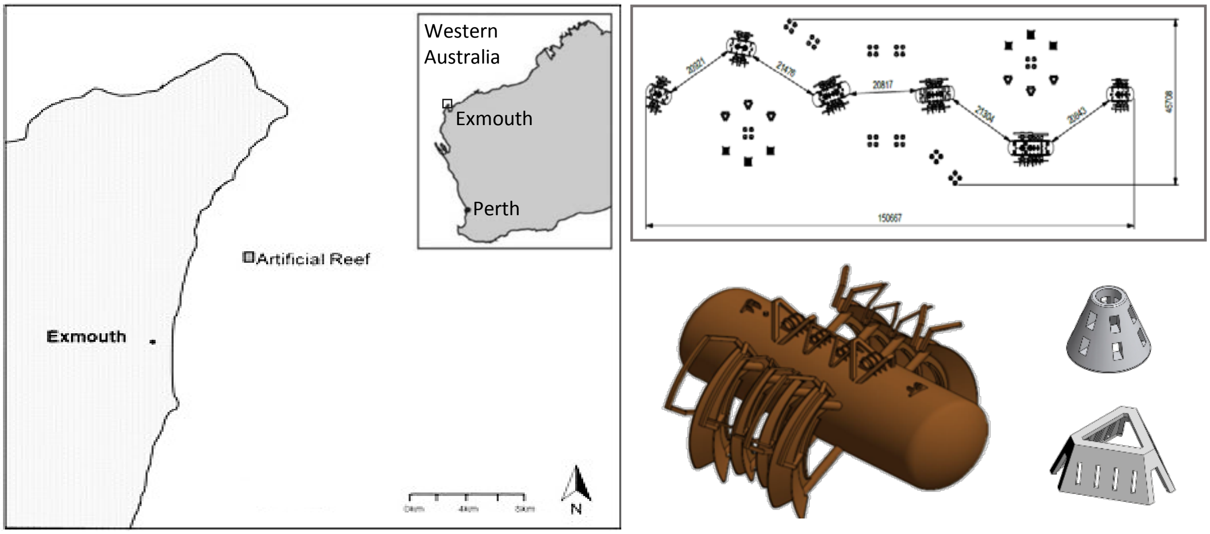

Figure 3: Location of the EIAR and the position and material used to develop the reef. Source: Harvey et al. 2020a

4.2 Economic valuation of artificial reefs

At the current time there is only a limited amount of primary data relevant to estimating the value of artificial reef structures in the North West. The approach adopted in this study therefore is to estimate the value of the reefs using a benefit/value transfer approach. This has two broad elements:

- The economic impact associated with the development of artificial structures
- The value (consumer surplus) that users derive from artificial structures

These elements can be described and quantified by a demand curve which is underpinned by a model of peoples' behaviour.

4.2.1 Direct economic impact

The direct economic impact associated with the development of artificial reefs encompasses the direct expenditure made by recreational fishers and divers in pursuing reef based activities. The direct expenditure can act as a lower bound on the value of the associated fishing (see below). There will also be indirect impacts following on from these direct expenditures (e.g. a fisher expends money for bait, ice, hooks at local tackle shops which has a direct impact on output). The indirect impacts arise when the industries supplying these goods and services to fishers/divers/tourists in turn demand goods and services from their suppliers. In turn these shops spend money on rent, electricity, fuel, materials etc. which generates output, incomes and employment in those industries supplying the local tackle shop sector. This is relevant for understanding how the wider economy might benefit from the activities of recreational fishers and divers and tourists. At this stage the information is too limited to account for tourists.

There is little information on participant numbers on recreational activities around artificial reefs in Western Australia. Therefore, we estimate the expenditure value of the reefs using expenditure estimates of recreational fishing, diving and tourism studies undertaken elsewhere suitably adjusted to allow for location and time.

4.2.2 Value derived from users

It needs to be recognized that participants in reef-related marine activities will derive a value or surplus that is over and above the expenditure or cost incurred to participate. In order to gain an understanding of the value of the recreational experiences associated with the proposed reef, we apply estimates of the willingness to pay for artificial reef activities, focussing on recreational fishing, derived from studies of compatible situations elsewhere.

Central to this approach is the extent to which an artificial structure is perceived differently and therefore has an intrinsically different value to a natural reef. If yes, then only studies directly dealing with artificial structures are relevant. However, it can be argued that once an artificial reef is developed and settled into the marine environment, recreational fishers will value the fishing experience in the same way that they value fishing at any other location. Species, catch, catch rates, accessibility, congestion and safety will drive the value of the fishing experience. Hence the value of recreational fishing can reasonably be based on relevant studies from comparable cases, whether based on artificial or natural reefs.

To understand how value is derived from recreational fishing, it is useful to begin with a model of recreational fisher behaviour. Such models have been an accepted part of the economics literature for many years, and assist in the analysis of value because they help to:

- Clarify how value is derived from the choices that recreational fishers make
- Allows inferences to be made about expenditures and value
- Help to put intelligible bounds on value

Assuming that fishers go fishing to maximize the value they derive from fishing a simple model implies that:

- The resource cost of going fishing is expenditure (money outlays plus opportunity cost of time)
- Fishers choose to expend these resources because the value derived from fishing is greater than or equal to the value of these resources expended in some other way, so

- The value of resources expended (money plus time) is a minimum or lower bound estimate of the value of recreational fishing

This principal components of the higher value that justifies incurring these resource costs are:

- Experiential value – related to the wider trip experience irrespective of whether any fish are caught and kept or released
- Sport value – related to the excitement of catching sporting species of fish irrespective of whether kept or released
- Food value - directly connected to kept catch of edible species

Looking at the value of recreational fishing imputed from the choices that fishers make enables analysis of policies such as bag limits and closures that impact the quantity and quality of options available to fishers, and so have the potential to directly enhance or diminish the value of recreational fishing, even if the resource cost is little impacted. It applies to artificial reefs in that the development of a successful reef will improve all aspects of the fishing experience without necessarily increasing the cost of undertaking the fishing activity.

The following diagram is a simple representation of this concept.

Assume a recreational fisher makes several trips per year to go fishing. The "price paid" for each trip is composed of money costs (trip, gear, and boat) and time cost as reflected in the opportunity lost by committing the time to fishing.

The financial cost includes:

- Direct per trip costs such as boat fuel, food, launch fees, bait and ice, plus the financial cost of land transport to get to the location of the fishing platform. The annual cost is the sum of the individual trip costs, or the average trip cost multiplied by the annual number of trips chosen
- Annual gear cost for items such as rods and reels, clothing, and other annual costs that are independent of fishing effort levels
- Annual boat costs which can be apportioned based on the percent of times the boat is used for recreational fishing

The time cost includes total trip time which is composed of:

- Travel time from residence to launch site or shore location
- Time spent fishing and
- Time spent on the water or at the shore location when not fishing
- The opportunity cost value of time which might be different for the different types of time

To the recreational fisher, the economic value of each trip is the maximum sum of money the fisher would be *willing to pay* for that trip. In the literature, the demand for a non-market good or service, such as recreational fishing, is expressed as the maximum willingness to pay (WTP) for that experience, and the demand to go fishing can be represented by a conventional demand curve making chosen trips per year a function of WTP for the trip. This is illustrated in Figure 4.

The total value derived from OC trips is the area under the demand curve or ABCO. Of this gross value, the shaded area EBCO is the cost of going fishing for OC trips. Assuming OC trips at average cost E is the optimal solution for the fisher, EBCO also is the lower bound on the value that can be ascribed to recreational fishing activity; because for all but the marginal trip at OC, the WTP for the trip exceeds the price paid as measured by the resource cost of going fishing. The excess of WTP over and above resource costs incurred is depicted by the triangle ABE, and is referred to in the literature as the consumer surplus from the recreational fishing experience

Hence, a more complete valuation is based on area ABCO which encompasses the experiential, the sport, and the food value of fishing.

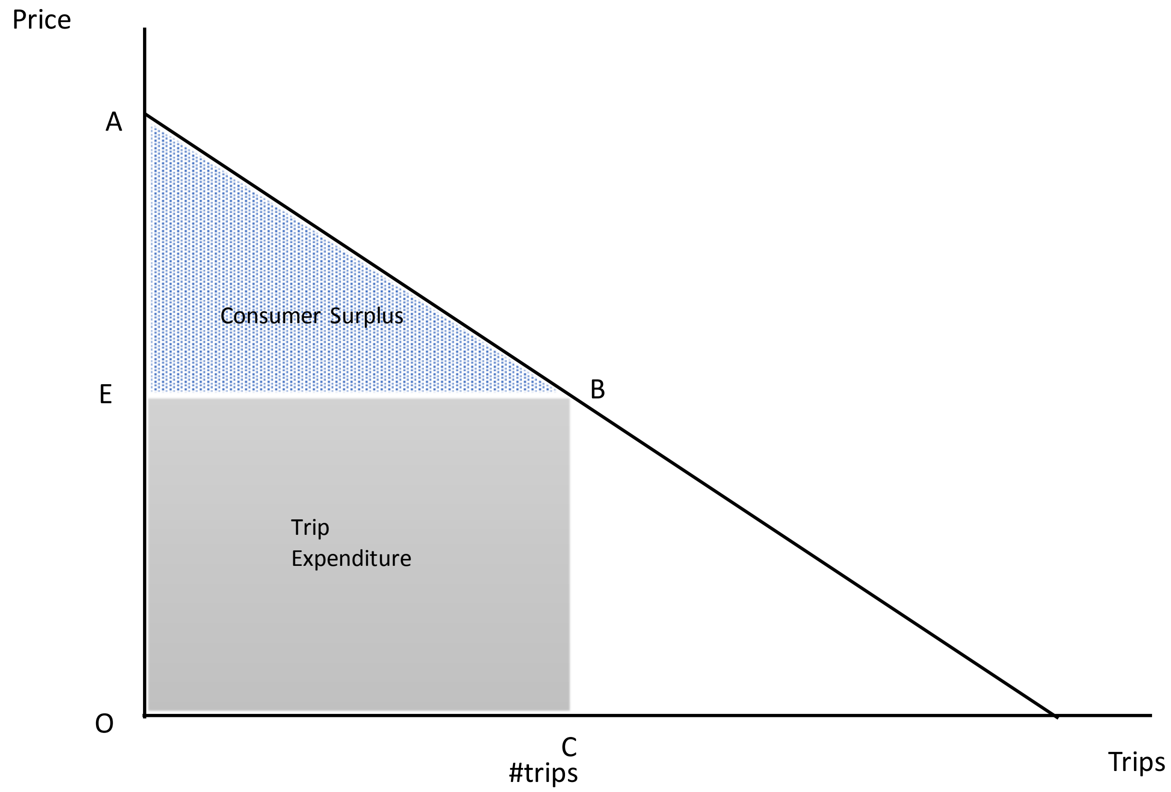

Figure 4: Expenditure and consumer surplus for recreational fishing

From the above diagram, value can be assessed as follows:

- At a minimum it is the expenditure the recreational fisher, diver or tourist incurs to access the site and pursue fishing, diving and other marine tourism activities.
- Over and above the expenditure there is the consumer surplus value.
- Combined, these are the gross value.

The addition of an artificial structure that supplements the natural structures, increases choice and improves the related ecology has the potential to enhance value as illustrated in the diagram below.

The improvement in the attractiveness of the area can be represented by a shift in the demand curve for fishing, diving and marine tourism in the area. There are two consequences of this.

First the experience of existing users is enhanced. This can be represented as an increase in the value of activities in the area equal to AFGB. This enhanced value is based on the current volume of activity (e.g. fishing trips/days, dives/dive days etc.) as reflected in OC. The underlying level of expenditure is still OEBC.

Second, the improved amenity of the area will increase activity levels (e.g. fishing trips/days, dives/dive days etc.). This increase in volume will in part be from existing users increasing their activity in the area and in part from new participants attracted to the area because of the improved fishing/diving/tourism opportunities afforded with the new structure in operation. The additional activity is CI. This causes an increase in expenditure on activities equal to CIHB and generates additional consumer surplus of BHG.

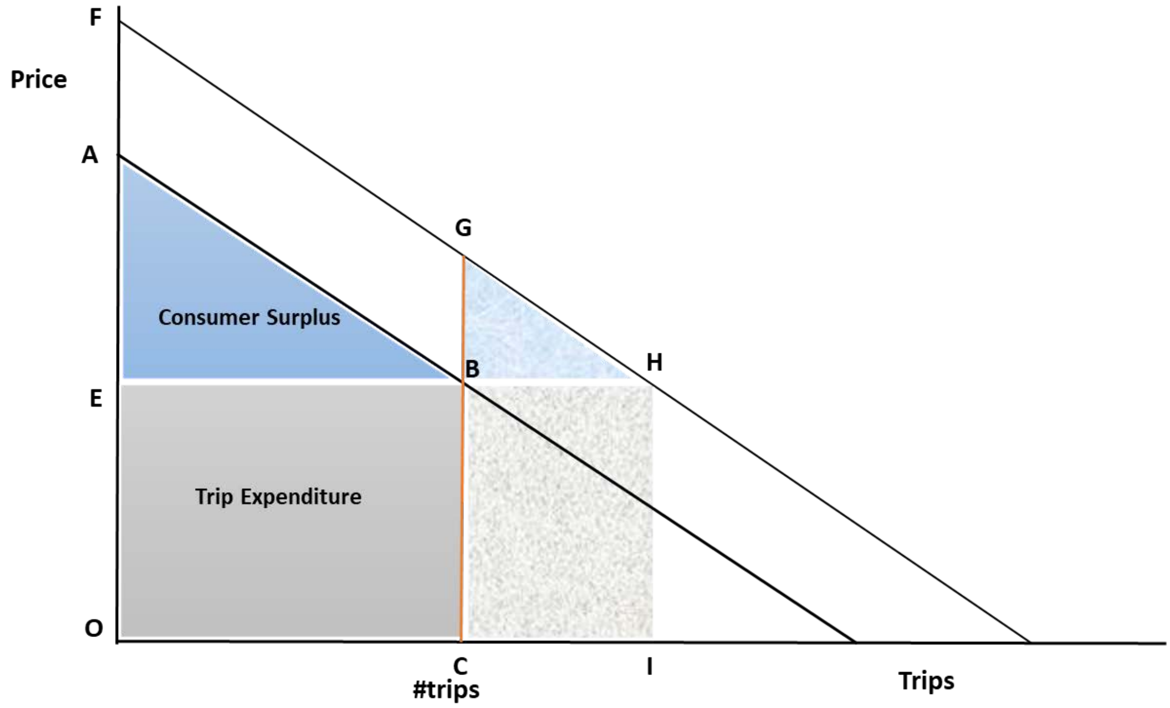

Figure 5: Expenditure and consumer surplus for recreational fishing following an improvement in fishing quality

In assessing the value of an artificial structure, we need estimates of:

- The current activity level OC and the potential increase in activity CI. This might be determined by studies of participation on the actual structure or, where data is not available, by applying response rates determined in comparable structures.
- The expenditure made on the estimated incremental activities. There is no reason to expect expenditures per unit (e.g. fishing trip or day) to be different between base and incremental activity. Hence current estimates of expenditure per day can be applied to estimated activity increase.
- The surplus on existing activity of ABGF and the consumer surplus on the incremental activity. This might be implied using benefit transfer whereby the estimated net willingness to pay for access to artificial reefs in other established locations or estimates of the increased value per trip that may arise because of improved catch.

In applying this to an artificial reef, we start with the expenditure.

The expenditures made by the recreational fisher/diver/tourist to access and participate in reef related activities cause direct and indirect economic impacts in the local and State economies. The direct impact derives from the expenditure incurred and is associated with additional output, incomes and employment associated with this expenditure on the goods and services required for their activities.

Estimating the consumer surplus that accrues over and above these direct expenditures is essential to understanding how the availability and use of an artificial reef contributes to overall fisher, diver and tourist welfare.

4.2.3 Valuation approaches

As described in the literature review above, there is an ongoing discussion about the capability of artificial reefs to produce new biomass vs attracting biomass from surrounding areas. 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.

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 apply two different approaches in this report:

- Approach 1: Upper value

  To estimate the upper value of the possible range of the economic impact from an artificial reef, this approach assumes 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 assumes 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.

5 The potential value of artificial reefs made from decommissioned oil and gas infrastructure off Onslow

The following analyses of available data and information from the literature are used to make an indicative assessment of the potential economic impact of artificial reef development made from decommissioned oil and gas infrastructure around Thevenard Island off Onslow in Western Australia. We follow two approaches, one which assumes new production of fish and new created trips to the area and one that assumes a sharing of created benefits among all users in the region. We also distinguish between two scenarios: i) leaving existing oil and gas structures in place and ii) re-purposing parts of the material for new artificial reefs.

5.1 Framework to estimate values

The base load for fishing expenditure is area OCBE in Figure 4. The potential future artificial reefs are offshore so fishing at that location requires a boat. Therefore, the relevant base is activity and expenditure by those fishing from a boat. The horizontal volume could be measured as boat days, fishing events or catch. Measured as boat days the vertical axis would be expenditure ("price") per day. Additional value generated by the structures would be measured as an increase in boat days and a willingness to pay for additional boat days. Additional boat days could be a combination of existing fishers staying longer and new fishers participating in the structure based activities. The value of these additional boat days would reflect both the catch and the boating experience sans catch.

Measured as catch, the vertical axis would be expenditure per unit of catch. Additional value is measured as the increase in catch due to fishing on the structures and the willingness to pay for additional catch. Using catch is the less attractive option because fishing experience can encompass, catch and keep, catch and release and non-catch value associated with fishing (e.g. spending time with family and friends). However, studies of willingness to pay have concentrated on catch so the bulk of the data relevant to the benefit transfer analysis is based on catch. It will be necessary to infer this value based on catch values. Focusing on boat days Table 2 shows the estimated boat days used for recreational fishing in Western Austral in 2015/16.

Table 2: Annual fishing effort, expressed as boat days and fishing events, for boat-based recreational fishing in Western Australia during 2015/16.

Region fished	**Boat days**	**Events**	**Hours fished**
North Coast	31,375	33,046	122,192
Gascoyne Coast	43,237	44,407	169,312
West Coast	271,311	285,157	740,815
South Coast	24,444	25,097	80,260
State-wide Total	370,368	387,707	1,112,579

Source: Ryan KL, Hall NG, Lai EK, Smallwood CB, Taylor SM, Wise BS 2017. State-wide survey of boat-based recreational fishing in Western Australia 2015/16. Fisheries Research Report No. 287, Department of Primary Industries and Regional Development, Western Australia. 205pp

The State-wide estimates are based on a survey of RFBL holders with 2,931 fishers 320,661 individual fish caught (kept or released), 39,416 boat days, 42,152 fishing events and 123,378 fishing hours. These data can act as a reference point to assist estimating a base load for analysis of Thevenard Island.

5.2 Private recreational fishing effort

Private recreational fishing effort includes boat launch events for boat ramps in the North Coast as the indicator of relevant effort (Table 3). The boat launch events are around 7.5% of State activity. Launch activity from Onslow and Thevenard Island ramps is about 3.2% of North Coast activity.

Table 3: Launch activity from North Coast boat ramps 2015/16 survey.

North Coast	% of North coast launchings	% State launchings
BROOME ENTRANCE POINT (1) BR	7.81%	0.59%
BROOME ENTRANCE POINT (2) BR	12.88%	0.97%
BROOME GANTHEUME POINT BR	4.05%	0.31%
BROOME PORT SMITH BR	1.16%	0.09%
BROOME TOWN BR	12.88%	0.97%
CAPE KERAUDREN BR	0.43%	0.03%
CLEAVERVILLE BR	0.43%	0.03%
COSSACK BR	0.58%	0.04%
DAMPIER BOAT HARBOUR BR	7.53%	0.57%
DAMPIER BR	1.45%	0.11%
DAMPIER TOWN BR	11.87%	0.90%
DERBY BR	1.30%	0.10%
DERBY TOWN BR	3.18%	0.24%
FORTESCUE RIVER BR	4.78%	0.36%
FORTY MILE BEACH BR	0.14%	0.01%
KARRATHA BACK BEACH BR	1.59%	0.12%
KARRATHA BOAT HARBOUR BR	0.72%	0.05%
KARRATHA BR	0.58%	0.04%
KARRATHA BR	0.14%	0.01%
KARRATHA BR	0.58%	0.04%
KARRATHA BURRUP BR	0.87%	0.07%
LAKE ARGYLE BR	0.14%	0.01%
LAKE KUNUNURRA BR	0.14%	0.01%
LAKE KUNUNURRA BR	1.30%	0.10%
ONSLOW BR	1.45%	0.11%
ONSLOW BR	1.74%	0.13%
PORT HEDLAND BOAT HARBOUR BR	4.63%	0.35%
PORT HEDLAND FINUCANE ISLAND BR	6.51%	0.49%
WYNDHAM ANTHON LANDING BR	2.89%	0.22%
WYNDHAM TOWN BR	6.22%	0.47%
Total North Coast	100.00%	7.55%
Total Western Australia		100.00%

Source: Estimated by author using data supplied by Department of Primary Industry and Regional Development for the analysis in McLeod and Linder (2018)

Applying this percent to the North Coast effort gives 998 as the North Coast boat days departing from Onslow and Thevenard ramps, pre-reef.

Questions were added to the WASHF survey to collect data on trip expenditures as part of the surveys undertaken for McLeod and Lindner (2018). Questions dealt with average expenditure per trip for food and drinks, bait and ice, boat fuel, parking and launch fees and other trip costs. These are the variable costs that are expected to change with the number of trips measured as boat days. Gear costs and boat costs were also collected as part of the survey. These were collected on a 12 months basis as they do not change with the number of trips at the margin within a year.

Additional trips arise either because current fishers increase trips per year or new fishers participating will incur trip costs. The per night and aggregate trip costs on food and drinks, bait and ice, boat fuel, parking and launch fees and other trip costs (based on the WASHF survey 2018) based on Onslow and Thevenard Island boat ramps are shown in Table 4.

Table 4: Aggregate trip expenditure for effort from Onslow and Thevenard boat ramps

Food and drink	Fuel for boat	Parking and launch fees	Bait and ice	Other trip costs	% Trips with nights away	Accommodation cost
Per day/night costs						
$169.16	$147.15	$4.53	$45.04	$53.43	56.72%	$121.45
Aggregate Costs						
$167,300.92	$145,532.14	$4,483.07	$44,542.69	$52,847.17	56.72%	$120,112.27
Aggregate Expenditure						
Expenditure	Cost per day					
$534,818.26	$540.77					

The expenditure of $534,818 is the annual expenditure made by fishers operating from Onslow boat ramps, equivalent to $541 per boat day. Translating this to the diagram of demand and expenditure this is the rectangle of current expenditure as shown by OCBE in Figure 4.

Assuming the demand curve through B is linear we can solve for the intercept A in two ways. Using an estimate of consumer surplus per day we can estimate aggregate consumer surplus for the 998 boat days and derive an estimate for the maximum price. Alternatively using an estimate of the price elasticity at the point B, we could calculate the maximum price. No specific data on these values exists for Onslow, nor Western Australia. Moreover, the literature is thin on meaningful estimates of these concepts.

In the recent McLeod and Linder (2018) the Recreation Use Values Database (RUVD) for North America was used as a basis for inferring an estimate of consumer surplus. The RUVD reviews and indexes estimates of consumer surplus from economic valuation studies of the use value derived from a wide range of recreational activities in the U.S. and Canada from 1958 to 2015 (Rosenberger, 2016).

The 2016 update contained 421 documents of studies that yielded 3,192 estimates of consumer surplus from twenty-one primary activity types in per standardised person per activity day units. The primary activity type relevant to the current study is “saltwater fishing”, for which the database studies contained 134 documents, almost all of which contained multiple estimates of consumer surplus. Some of these multiple estimates reflect plausible differences in values of consumer surplus from the fish species targeted by recreational fishers, but much of the variability reflected alternative estimation techniques. After filtering out documents classed as PhD Dissertation; Working Paper; or Proceedings Paper, 121 documents remained comprising published journal articles; government agency or university report; or consulting report; that yielded some 15,285 estimates of consumer surplus from saltwater fishing.

For consistency these estimates were adjusted for time and currency differences. After standardising these 15,285 consumer surplus estimates to 2016 USD values, the overall average was USD 126.32 per person per fishing day. However, the span was very wide, ranging from less than USD 1 per day per person to nearly USD 700 per day per person. The judgment was made to exclude outliers that were either less than USD 10 or greater than USD 500, which left 100 estimates of consumer surplus with an average value of USD 133.75 per person per fishing day. Converted to AUD at the prevailing exchange rate of AUD1.33 per USD yields an estimate of consumer surplus from recreational fishing of $178 per person per fishing day.

Some of the higher estimated values were for prized sport fish such as Blue Fin Tuna with an upper bound of USD339.59 and an average of USD268.94, and an average of USD336.98 per person per fishing day for unspecified species of Tuna. The estimated consumer surplus from recreational fishing for other most other fish species, including many keenly sought species such as snapper and grouper was substantially less. For instance, the average of 15 estimates of consumer surplus for associated fish species, including snapper, sea trout, grouper, catfish, and red snapper, was USD79.10. Converted to AUD at the prevailing exchange rate of AUD1.33 per USD yields an estimate of consumer surplus from recreational fishing of $105 per person per fishing day. Applying the $178 dollar figure yields a consumer surplus estimate of $2.71 million dollars which implies an intercept price of $1032 and a price elasticity of -1.90. As the consumer surplus estimate increases the implied intercept price goes up and the implied price elasticity deceases in absolute value (is more inelastic). This is shown in Table 5 for a range of consumer surplus and elasticity estimates, ranging from $105 through to $300. Using the model as outlined in Figure 4 we can infer the elasticity of demand using the consumer surplus estimate, or infer consumer surplus by assuming a price elasticity and hence inferring the slope of the demand curve. Estimates of the price elasticity of demand for recreational fishing are few and relatively poorly documented so we adopt the former approach: taking an estimate of consumer surplus from the literature and inferring the elasticity of demand and demand curve. We are using for our indicative calculations a lower end CS with a “reasonable” implied price elasticity. However, it needs to be recognized that the experiences being created are unique and until original survey data is collected, a refined estimate is not possible.

Table 5: Implied price elasticity at different consumer surplus per trip value

Trips	Consumer surplus per trip ($)	Consumer surplus	Intercept price	Implied price elasticity at current trips
998	105	104790	750	-2.57
998	178	177644	896	-1.52
998	200	199600	940	-1.35
998	250	249500	1040	-1.08
998	300	299400	1140	-0.90

Using the $178 per day figure and assuming the demand curve through B is linear, we estimate the aggregate consumer surplus for the 998 days to be $177,644 and derive an estimate for the maximum price of $896 (Figure 6).

5.2.1 Approach 1: Upper value

To estimate the economic impact from an artificial reef made out of oil and gas structure around Thevenard Island, we start with the approach that assumes that the additional fish available around the reef are new production and will attract new fishers to the area (Figure 6). This assumption is supported by available information of reef activity (Recfishwest, unpublished data) and information gathered in a focus group with 5 Recfishwest representatives who expect that there will be an increase in private boat activity for both fishing and diving once the location around the existing structures is open for fishing and diving activities. However, depending on the final location of the new artificial reef, this might not be accurate.

The Onslow boat ramp locations are isolated. This is reflected in the much smaller number of boat launches from these locations compared to the Exmouth launch number documented previously. In part this appears to be due to the greater distance from Perth and in part it is due to the significant ocean distance that needs to be travelled to reach attractive fishing areas. The facilities available in Onslow and the boat ramp facilities have also been suggested as a limitation

Making the area around the Thevenard structures available is a quantum change. It offers potentially rich fishing and diving opportunities much closer to shore and within a safer area close to Thevenard Island. The low current base and the absence of any reliable data on intentions from fishers mean that estimating the likely additional number of participants that go to Onslow and Thevenard Island as a result of any artificial reefing is difficult.

Rather than nominate an exact number we illustrate what might be the result with increases of 15%, 20% and 30% in total fishing trips from the current base load. The results are shown in Table 6. Assuming that they have the same expenditure patterns as current fishers, with a 15% increase in activity which is 150 extra boat days, aggregate expenditure increases by around $80,840 per year. Using the same analysis as for the base case with a surplus per day of $178, aggregate consumer surplus is around $26,650. If the increase in activity is 30%, aggregate expenditure increases by $161,670 per year and the associated consumer surplus is around $53,300.

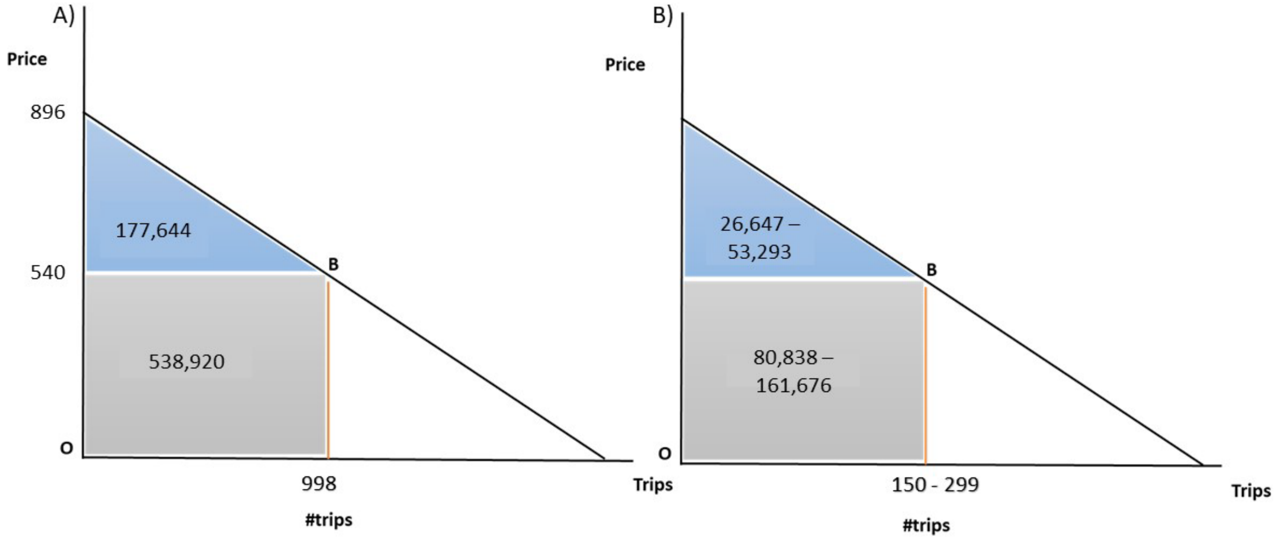

Figure 6: Economic value of the status quo fishing on existing sites (A) and the value of the new artificial reef(s) if the site attracts new fishers (B).

It is important to note that the area around the current structures is currently not available to private fishing boats, private diving boats or charter fishing boats. Therefore, while the above increments illustrate what a transformation of the base load might imply, any increase is unlikely to be instantaneous. It may take time for fishers to become aware of the artificial reef and begin investigations. Once open, the opportunities will need to be appropriately promoted and managed. Nevertheless, based on feedback from charter operators, who are currently in the best position to estimate what opportunities the area offers, for private fishers and divers, a significant increase in private boating activity is expected.

Table 6: Incremental consumer surplus (CS) from additional fishing activity at Onslow boat ramps

Base trips	Expenditure per trip	CS per trip	% increase	# Trips increase	Additional expenditure	CS
998	$540	$178	15%	150	$80,838	$26,647
998	$540	$178	20%	200	$107,784	$35,529
998	$540	$178	30%	299	$161,676	$53,293

5.2.2 Approach 2: Lower value

An alternative approach is to estimate how the presence of the new site will cause the demand to fish in the area to shift. This will induce an increase in the value (on average) to existing fishers, plus an increase in visitors. The lift in demand is due to the whole area being perceived as more attractive because of the development of the reefs. As already discussed, this can arise because the "portfolio" of opportunities is increased and depending on the responsiveness of demand, the fishing and diving conditions should improve at all locations on average as consumers spread around the locations to pursue activities inclusive of the new reef.

The starting point for this analysis are the status quo values from section 7.1 above. These numbers are assumed to apply for the catch rate for reef fish of 4.2 per trip (Department of Primary Industry and Regional Development, unpublished data). We use the WTP per fish caught of $9.47 (Raguragavan et al. 2013) and calculate the additional consumer surplus which increases with the increase in the catch rate. Given our uncertainty about the future use of the newly available structures, we apply the additional consumer surplus on 15%, 20% and 30% of visitors visiting the new reef. The distribution of catch rates and the associated consumer surplus is shown in Figure 7.

<u>Scenario 1: Leave in place</u>

Current estimates from ecological data indicate that there are 98 fish species associated with the nine Thevenard oil and gas structures out of which 40 are routinely retained by recreational and commercial fishers (Harvey, unpublished data). The biomass on the Thevenard structures is approximately 250 and 356 times higher than on adjacent natural reefs and soft sediment, respectively (Harvey, unpublished data). If the structures were left in place and made available to recreational fishing with all biomass preserved, this would potentially result in a strong increase in catch rate. However, the new catch rate might not be proportional to the difference in biomass because of bag limits for recreational fishing activities (Table 7). It also has to be recognised that the current estimates of ecological data reflect the status of the oil and gas infrastructure when it has been protected from fishing, and the equilibrium level of biomass, if fishing were to proceed, would be lower.

Table 7: Bag limits in the North Coast bioregion that apply to different finfish categories that are present around Thevenard oil and gas infrastructure.

Category	**Bag limit**
Demersal finfish	5
Large pelagic finfish	3
Nearshore/estuarine finfish	16
All other species of finfish	30
Total	54

Source: Department of Primary Industries and Regional Development 2019: Recreational fishing guide 2020.

Based on the bag limits, the maximum number of fish one fisher is allowed to catch on artificial structures offshore from Onslow is 54 fish per day. For example, if we used this as that maximum legal catch rate and 15% of trips would go to the reef, the increase in demand would generate an additional 181 trips to the area, and produce an additional consumer surplus of $92,153 and an additional expenditure of $97,790. If 20% of trips were going to the new reef, the site could produce 231 extra trips, $124,954 of extra revenues and an additional consumer surplus of $124,749. With 30% of total trips in the area visiting the new reef, these benefits could rise to an extra 320 trips, additional revenues of $173,013 and $189,872 of additional consumer surplus (Figure 7).

Scenario 2: Re-purpose parts of the oil and gas infrastructure to create new artificial reefs

In the scenario where oil and gas structures around Thevenard Island are transported to a designated reefing location, it is possible that the fish communities currently associated with structures will disperse or be lost. Under this scenario, the biomass on the new artificial reef will have to start growing on an initially uninhabited artificial structure. Given the proximity of the site to Exmouth, we can expect a development of marine life and therefore a catch rate similar to the one of the EIAR. After about one year of the deployment of the EIAR, biomass was measured to be about three times higher than on adjacent natural habitat and the catch rate was estimated to be 10.89 fish per day (see section 8.2.2). Applying this catch rate to artificial reefs made out of Thevenard oil and gas infrastructure, it would generate between 24 and 43 new trips, $13,137 and $23,242 in extra revenues and an additional consumer surplus between $10,087 and $18,330 depending on the percentage of trips to the new artificial reef.

However, as previously discussed, there is an uncertainty about the size, location and condition of a future artificial reef. Moreover, the ecology on the structures may change over time depending on environmental factors and fishing pressure. Therefore, a catch rate and the resulting additional revenues and consumer surplus it is generating could lie somewhere between the values above.

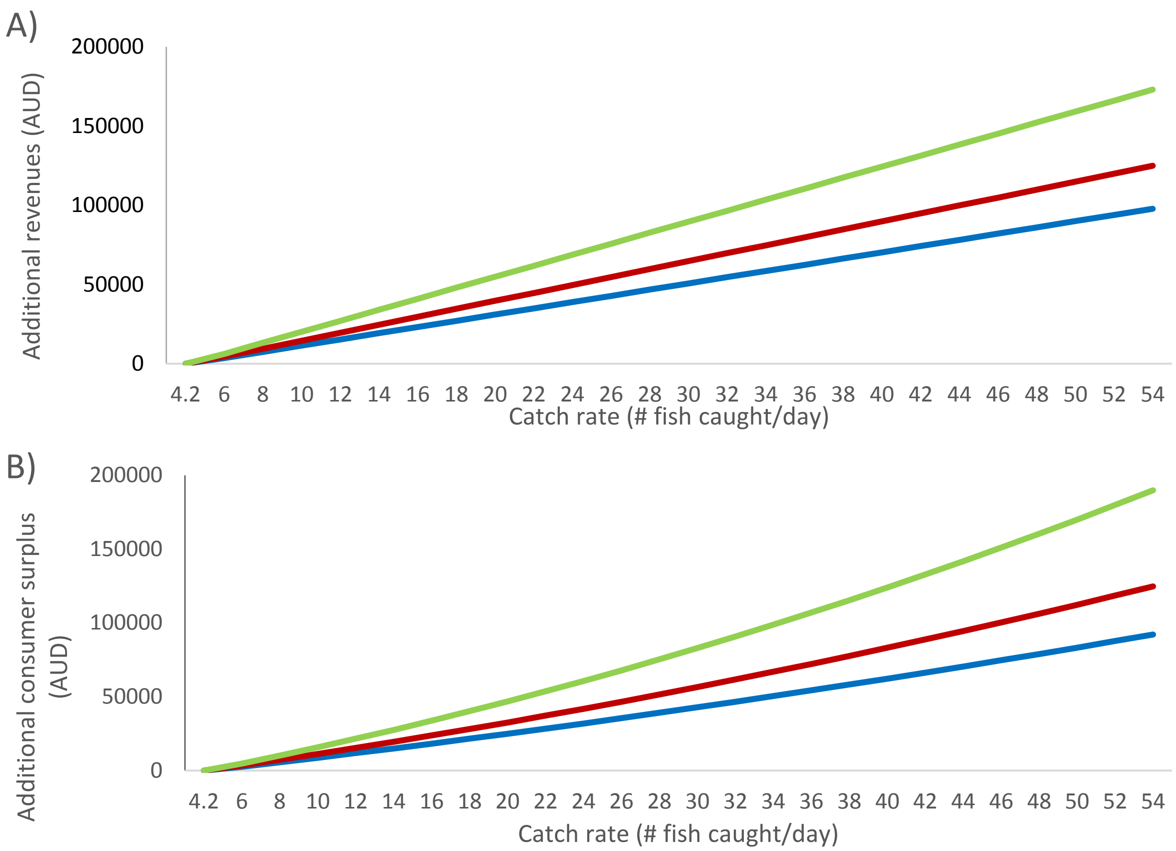

Figure 7: Relationship between catch rate and A) additional trip expenditures and B) additional consumer surplus from recreational fishers that visit Thevenard oil and gas structures. The colours of the lines indicate the percentage of trips going to the structures: Blue = 15%, red = 20% and green = 30% of total trips in the area.

In summary these two approaches (new production and shift in demand) give us an idea about the potential economic benefits that the artificial reef(s) made out of Thevenard oil and gas infrastructure could bring to recreational fishers in the area. Approach one indicates that the development of an artificial reef off Onslow could increase the number of trips to the Onslow and Thevenard Island area by between approximately 150 and 299 per year. The results of the second approach suggest a range of 24 to 320 extra trips to the new reefs per year. Under the given assumptions and depending on the approaches and scenarios, the increase in annual expenditures due to the new artificial reefs could lie between $13,137 and $173,031 and the additional consumer surplus between $10,087 and $189,872 per year. It is important to notice that these benefits are annual values and would accumulate to larger benefits over the years. At times it is of interest to compare the value of the benefit stream to e.g. the initial costs of provision. However, future values have to be discounted and expressed in net present values. Table 8 shows the net present value for the benefits over the next ten years for a low, medium and high discount rate. It is important to note that these calculations assume that the estimated benefit stream will be sustained over the whole time period, although ecological and economic uncertainties may lead to greater uncertainty about the evolution of values.

Table 8: Net present value of economic benefits ($'000) from Thevenard artificial reefs over 10 years with low medium and high discount rates. Benefits are given for lower and upper bound estimates of the total annual economic value of artificial reefs (expenditures and consumer surplus).

Total annual benefit	Low (4%)	Medium (7%)	High (10%)
Lower bound: $23	188	163	143
Upper bound:$363	2,943	2,548	2,228

5.3 Charter boat operators

The analysis above has been based on data for private recreational fishers. However, given the location and potential quality of the fishing experience offered, the site may provide significant attractions for charter boat operators. At the moment, there are ten charter boats with an average capacity of ten passengers each operating in the area of Thevenard Island. These are based in Exmouth, Onslow and on Thevenard Island and mostly visit the Mackerel Islands and Montebello Islands. The most common activity is recreational fishing but free diving, snorkelling and scuba diving activities are also done occasionally. Operations occur during the dry season between April and November and follow a roster of one week trips. The trip costs range between $3000 and $4000 per person. Based on these figures, revenues from charter boat operations under the status quo are estimated to be approximately $8.75 million per season. Given that the oil and gas facilities around Thevenard Island are closed, at this moment none of these revenues can be attributed to them.

5.3.1 Potential economic value from Thevenard oil and gas infrastructure

A focus group with the charter boat sector (conducted in March 2020) that operates in the region revealed that the availability of Thevenard oil and gas infrastructure could cause the following changes to the charter boat and tourism industry in the region:

1) Establishment of a new market for companies offering one day trips to the artificial reef(s) because they are only about two hours away from Onslow.
2) Live-aboard trips have to be occasionally cancelled due to rough weather conditions. The area around Thevenard Islands is closer to launching locations than the final destination of these trips and is fairly protected from rough weather conditions. Therefore, the newly available structures could be used as a substitute site when it is too rough to go to e.g. the Montebello Islands and increase the number of trips the operator can do. This also saves operation costs.
3) Increased customer satisfaction because charter boat operators could start high quality recreational activities much sooner within the trip (within two hours from Onslow, rather than 6 hours of navigation to the Montebello Islands).
4) Attraction of more tourists to Onslow with flow-on effects such as an increased variety of other small businesses like restaurants and souvenir shops.

At this stage it is not possible to quantify the economic value of these benefits.

5.4 Commercial fishing operators, including aquarium fish

There are a total of seven different commercial fisheries with that operate in the area that would be relevant to the decommissioning of Thevenard oil and gas infrastructure. Fisheries target beche de mer, mackerels, prawns, oysters, a range of scale fish using lines, crabs, and shells. These fisheries encompass 70 commercial fisheries licenses (Shea, 2017). At this moment, the area around the current structures is off limits for commercial fishing. However, once the new structures are in place the area could be made available to commercial fishing alongside recreational fishing and dive tourism.

The initial investigations of the ecology on the structures have identified a total of 40 species of commercial relevance and with established presence in the commercial market place (Harvey et al., unpublished data). Of those identified, the following species have a high market price: Rankin Cod, Rosy Snapper, Grass Emperor, Duskytail Grouper, Golden Snapper and Pearl Perch, Spangled Emperor, Mangrove Jack and Pearl Perch and Pink Snapper. Species identified that have slightly lower commercial values include Spangled Emperor, Mangrove Jack, Saddletail Snapper, Crimson Snapper, a range of Wrasses and Golden Trevally.

Enhanced value for commercial fishers is possible because:

1) Species that are commercially well established have been identified.
2) The biomass in the area is currently not fished commercially and represents a potential new opportunity for commercial fishers.
3) If this biomass is deemed to be independent of biomass currently fished outside of the area, it represents a potential expansion of the commercial catch.
4) If the biomass within the currently restricted area is deemed to be part of the currently fished biomass such that an increase in catch may not be permitted, the expanded area can still result in improved fishing efficiency.
5) If the structures cause spill-over effects into surrounding fishing areas, commercial fisheries might already benefit from the structures. These benefits could be reduced or lost if (some of the) structures were completely removed.

At this stage it is not possible to quantify the economic value of these benefits because the commercial catch that would be available for each of these species is not determined. This would be subject to further stock assessment within and outside of the area preparatory to establishing a management plan including consultation with stakeholders.

Harvesting aquarium is a specialised activity with 12 commercial licences in WA. There is a harvest strategy covering aquarium fish (DPIRD, 2018). A total of 20 aquarium species have been identified around the structures that are deemed to be commercially valuable and are incorporated in the current harvest strategy (Harvey et al, unpublished data). These include Clark's Anemonefish, Yellowtail Fusilier, Scribbled and Yellowtail Angelfish, Orangebanded Coralfish, Three-spot Humbug, Red Lionfish and Moon Wrasse. The availability of area around the new structures for fishing may offer an opportunity to recalibrate the harvest strategy for aquarium fish based on the species identified and a final assessment of the stock impact.

5.5 Diving activities

Diving activities are here defined as free diving, snorkelling and scuba diving for non-extractive purposes. As mentioned above, dive activities are offered by charter boat operators in the region around Thevenard Island.

If some of the Thevenard infrastructure were made available for dive tourism, this could diversify the economy in the region and make it more resilient. Under the assumption that this would provide a high quality dive destination there could be:

1) An establishment of a new market for one day trips because Thevenard is only about 2h away from Onslow,
2) More demand for dive tourism on live-aboard charter boat operators,
3) An increase in demand from private boat owners going diving on the structures, and
4) An attraction of more tourism to Onslow which could increase a variety of other small businesses (restaurants, souvenir shops, etc).

Currently, oil and gas structures are in depth of maximal 18 m and reach the surface which is accessible to all these activities. However, depending on the decommissioning option and a new location of the structures, free diving and snorkelling activities might not be feasible.

5.5.1 Potential consumer surplus from diving/snorkelling

There is very little evidence to allow an estimate of the potential expenditure and consumer surplus associated with diving/snorkelling at the location of the structures off Thevenard Island. This is essentially because in the absence of rigorous surveys of diving and snorkelling participation by destination for Western Australia, there is no meaningful base load estimate to start the calculation with as there was for fishing.

However, an indicative estimate is possible using a range of third-party sources. Surf Life Saving Australia (SLSA) produces a National Coastal Safety Report that estimates participation in diving and snorkelling by State. The estimates for Western Australia from the 2019 report are given in Table 9.

Table 9: Participation in diving and snorkelling and potential expenditure

	Participants	Frequent/dedicated	% to Thevenard	Thevenard trips
Snorkelling				
Australia	1,700,000	400,000		
Western Australia	170,000	40,000	5%	2,000
Scuba				
Australia	600,000	200,000		
Western Australia	24,000	8,000	5%	400
Total				2,400
Average spend per dive trip				$618.28
Total expenditure				$1,483,879.97

SLSA report an estimated 170,000 snorkelling participants and 24,000 diving participants in Western Australia. Of these, 40,000 snorkelers and 8,000 divers are estimated to be frequent/dedicated participants. We take this as the number of participants likely to consider the Thevenard Island location, at least in the first instance. If we assume that 5% of these could be enticed to experience the waters around the decommissioned structures, then around 2,400 person would make trips to the area per annum.

In their study of shark diving in Western Australia, Huveneers et al (2017) estimated trip expenditures for 2013/14 of $524. In 2018 values this is around $628 per trip. In the absence of an equivalent estimate for snorkelling, we apply this estimate to both snorkelling and diving. This is equivalent to $1.48 million for 2,400 participants. This can be translated into a consumer surplus measure by assuming a straight line demand curve and an associated price elasticity (Table 10).

Table 10: Consumer surplus from diving

	Value
Trips	2,400
Expenditure/trip	$618.00
Expenditure	$1,483,200.00
Price elasticity of demand	-0.85
Slope	-3.30
Intercept price	$1,345.06
Consumer surplus	$872,470.59
Consumer surplus /trip	$363.53
USD reference	$272.65

Using a price elasticity of -0.85 at a price -quantity combination of ($618,240) implies a consumer surplus of around $872,400 which is $363 per trip. Converted to USD at the long run exchange rate of USD/AUD0.75 this is equivalent to USD272. By way of comparison, in their study of the WTP for diving day trips, Ditton et al estimated a WTP between USD256.58 and 270.67. However, the ultimate numbers will depend on the final form of the structures available, the quality of the diving/snorkelling opportunities, the quality of the onshore facilities as well as promotional activity.

6 The potential value of the Exmouth Integrated Artificial Reef

This section analyses the available data and information from the literature to make an indicative assessment of the potential impact of the EIAR in Western Australia. This serves as an example of the benefits that can arise from artificial reefs partly made out of oil and gas structures in the region. The EIAR is offshore so activities at that location requires a boat. The impact from the artificial reef on activities in the area will ultimately depend on the development of the reef environment over time and how existing and new users will change their behaviour in response. Therefore, the following sections follow a similar rationale as Section 7.

6.1 Share of fishing effort attributable to Exmouth

Exmouth sits within the Gascoyne Coast bio region. Taking boat activity as the indicator of relevant effort, we look at launch events for boat ramps in the Gascoyne Coast (Table 11). The boat launch events are around 10.7% of State activity. Launch activity from Exmouth ramps is about 35.2% of Gascoyne Coast Activity. Applying this percent to the Gascoyne Coast effort gives 15,210 as the Gascoyne Boat days departing from Exmouth ramps, pre-reef.

Table 11: Launch activity from Gascoyne Coast boat ramps 2015/16 survey.

Boat ramp location	% Boats launched WA	% Boats launched Australia
CARNARVON BLOW HOLES BR	0.21%	0.02%
CARNARVON BOAT HARBOUR BR	5.64%	0.60%
CARNARVON PELICAN POINT BR	9.13%	0.97%
CORAL BAY GNARALOO BR	7.59%	0.81%
CORAL BAY MONKS HEAD BR	9.64%	1.03%
CORAL BAY WAROORA STATION BR	1.54%	0.16%
DENHAM BR	0.82%	0.09%
DENHAM BR	18.26%	1.95%
DENMARK BR	0.92%	0.10%
DENMARK BR	0.82%	0.09%
EXMOUTH BOAT HARBOUR BR	9.54%	1.02%
EXMOUTH BUNDEGI BR	6.36%	0.68%
EXMOUTH TANTABIDDI BR	19.28%	2.06%
MONKEY MIA BR	6.15%	0.66%
NANGA BR	4.10%	0.44%
Total	100.00%	10.66%
Total WA		100.00%

Source: Estimated by author using data supplied by Department of Primary Industry and Regional Development for the analysis in McLeod and Linder (2018)

Additional trips arise either because current fishers increase trips per year or new fishers participating will incur trip costs. The per night and aggregate trip costs on food and drinks, bait and ice, boat fuel, parking and launch fees and other trip costs (based on the WASHF survey 2018) based on Exmouth boat ramps are shown in Table 12.

Table 12: Aggregate trip expenditure for effort from Exmouth boat ramps

Food and drink	Fuel for boat	Parking and launch fees	Bait and ice	Other trip costs	% Trips with nights away	Average accommodation cost per night
Per day/night costs						
$232.25	$290.64	$4.62	$69.22	$9.52	$0.51	$137.09
Aggregate costs						
$3,532,658.97	$4,420,847.38	$70,306.85	$1,052,852.10	$144,733.92		$1,072,823.54
Aggregate expenditure						
Expenditure	Cost per day					
$10,294,222.76	$676.78					

The expenditure of $10.294 million is the annual expenditure made by fishers operating from Exmouth boat ramps, equivalent to $676 per boat day. Translating this to the diagram of demand and expenditure this is the rectangle of current expenditure as shown by OCBE in Figure 4. As in section 7 above, we use the consumer surplus value of $178 per day which was identified as the most appropriate value (depending on target species and the realism of the implied elasticity), giving an estimate of consumer surplus of $3.8m (Figure 8)

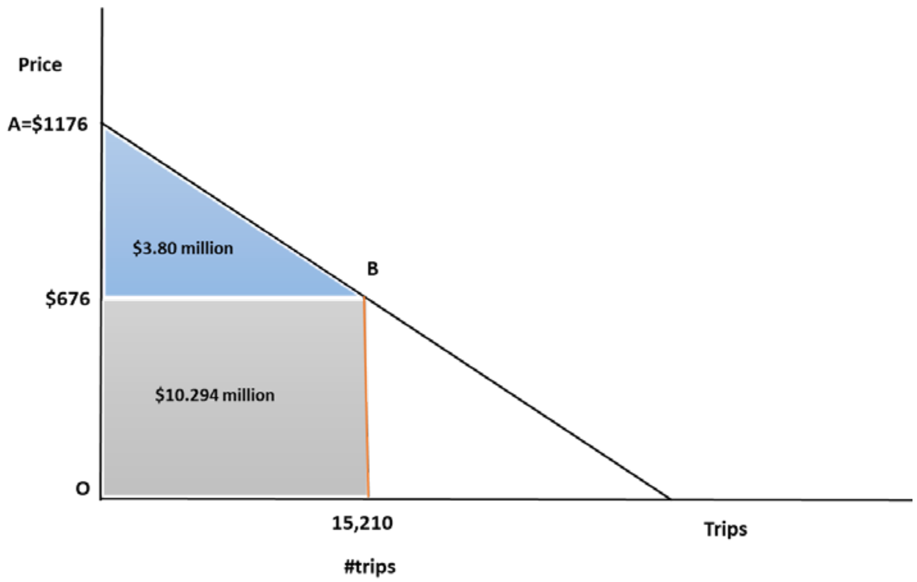

Figure 8: Consumer surplus for fishing from Exmouth boat ramps

6.2 Economic value of the Exmouth Integrated Artificial Reef

Given the early age of the EIAR, detailed surveys have yet to be undertaken to assess how fishers might respond and the final likely impact on the marine ecology and its impact on fishing have yet to be determined. That being the case we develop indicative estimates of potential values based on a range of assumptions.

6.2.1 Approach 1: Upper value

Approach 1 assumes that the additional fish available around the reef are new production and will attract new fishers to the area. Existing fishing opportunities will be unaffected. This is represented in Figure 9.

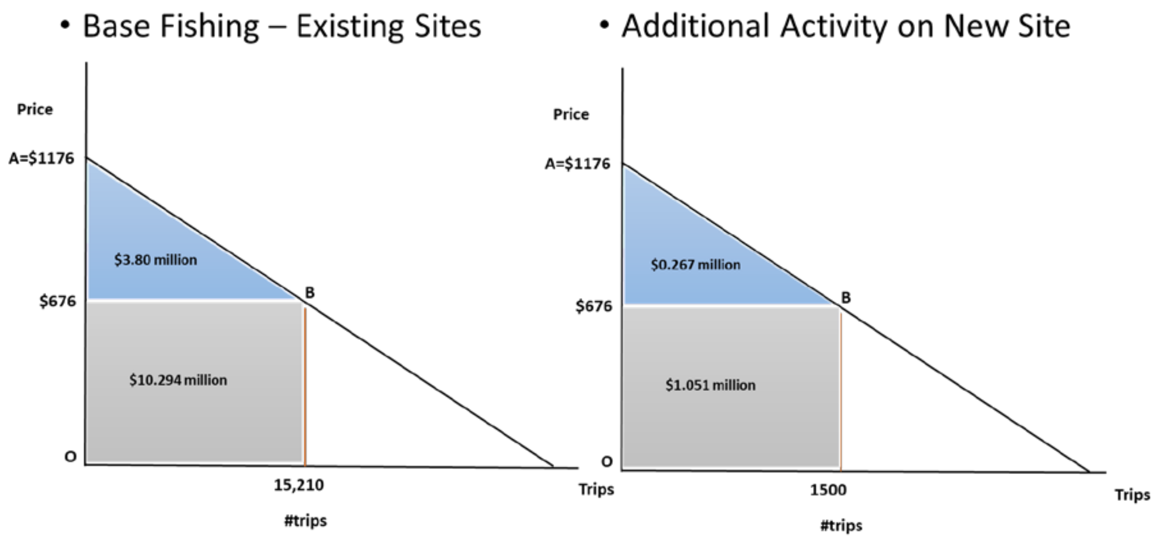

Figure 9: Value of the artificial reef when new site attracts new fishers.

Based on the available information of reef activity (Recfishest, unpublished data), we estimate that the likely additional number of participants that go to the EIAR is 10% of total fishing trips which is 1,500. Assuming that they have the same expenditure patterns as current fishers, aggregate expenditure increases by $1.051 million per year. Using the same analysis as for the base case with a surplus per day of $178, aggregate consumer surplus is $0.267 million. Although this is based on values consistent with the estimates in the literature, the actual demand for the reef may be different from the demand for existing sites. More accurate assessment would require detailed surveys of potential users. The model above treats the new location as a separate entity added to the system, with no impact on the rest of the system.

6.2.2 Approach 2: Lower value

Under approach 2, we consider the increase in the value (on average) to existing fishers, plus an increase in visitors due to the shift in demand to fish in the area. The starting point for this analysis is the base set of values with 15210 trips and a price of $676/trip and $10.3 million expenditure. Using the base assumption of $178 per trip (day) consumer surplus provides the base estimate or initial consumer surplus $3.8 million.

These numbers are assumed to apply for the catch rate for reef fish of 4.2 per trip (Department of Primary Industry and Regional Development, unpublished data). Current estimates from ecological data are that the artificial reef has approximately three times more fish than on adjacent natural reefs (Harvey, unpublished data). We use parameter from Raguragavan et al. (2013) to estimate how this increase in fish abundance translates into a higher catch rate. Using an elasticity of 0.53, the catch rate at the artificial reef increases by 6.68 fish/trip in comparison with adjacent natural reefs. Added to the current catch rate this gives a new total catch rate for fishers on the artificial reef of 10.89.

This increase in the catch rate generates increased consumer surplus for the fishers that visit the reef. We assume that this is 10% of all current trips (Recfishwest, unpublished data). The extra WTP per trip for the 10% of trips with the increased catch rate is estimated by multiplying the increase in catch rate (6.68) by the willingness to pay per reef fish. Until detailed surveys are completed, we are transferring estimates from previous studies to this catch. Raguragavan et al. (2013) estimate the willingness to pay at $9.47 per fish. This gives an extra value per trip of $63.354 or $74.753/trip in 2018 dollars for fishers that visit the reef.

This increased value is effectively spread across the whole population. At $74.75 for 1521 trips to the reef (10% of trips), the consumer surplus is $113,699. Across the whole population of trips this is equal to $7.475 per trip. On average for the existing population the availability of higher catch rates on the new reef adds $7.475 in consumer surplus per trip. This is appropriately represented as an increase in demand (shift in the demand curve) of $7.475 per trip.

The shift in the demand curve will also increases the number of trips that people make to the area. If we accept the base starting conditions as outlined above, the slope of the new demand curve is the same as the base curve. A shift equal to $7.475 increases trips by 227.4. The consumer surplus from these new trips is $848 which can be added to the overall surplus. Total consumer surplus is $114.55. This is illustrated in Figure 10.

In summary, these two approaches give us a range. On the current available evidence, the artificial reef has increased the number of trips to the Exmouth area at least by 227 and at the most by 1521 and that depending on these approaches the increase in consumer surplus varies from $114,500 to $267,000.

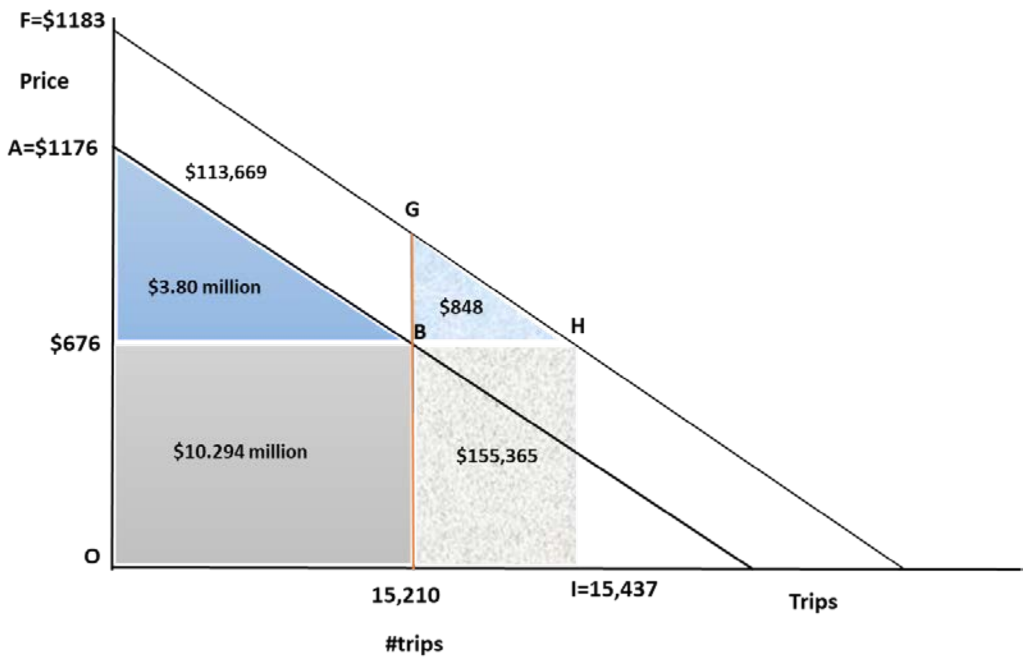

Figure 10: Increase in value due to an improvement in overall fishing quality (movement of lines not to scale).

6.3 Expenditure Impact

The current expenditure by fishers and the incremental expenditure that follows from the reef generate positive economic impacts for Exmouth. These are given in Table 13 based on the Exmouth IO table available from AURIN. These are indicative. A potential more accurate assessment could be made once the numbers are refined by using the REMPLAN model or the .ID impact module of the .ID demographic system depending on which one the Exmouth Shire has a subscription for.

The base expenditure has economic impacts equal to around 100 FTE. The estimated increment is equivalent to around 10 FTE, although as is noted elsewhere there are additional impacts that cannot be quantified at this time, for example the potential impact on general tourism or on charter boat activities that will grow after the full impact of the reef structure can be marketed.

Table 13: Output and employment impact of fishing related expenditures

Base	Expenditure ($mill)	Output multiplier T2	Employment multiplier T2	Output impact	Employment FTE/$mill	Direct FTE's	Total FTEs'
Recreational services	$9.22	2.26	1.76	$20.84	5.37	49.52	87.16
Accommodation	$1.07	2.02	1.49	$2.17	8.2	8.79	13.10
Total	$10.29			$23.01		58.31	100.26
Increment							
Recreational services	$0.94	2.26	1.76	$2.13	5.37	5.05	8.89
Accommodation	$0.11	2.02	1.49	$0.22	8.2	0.90	1.34
Total	$1.05			$2.35			10.23

7 Discussion

In this report we have predicted the economic value generated from man-made marine structures based in the waters off Onslow and Exmouth, Western Australia using available data and literature. The study provides an indication of the values that may be generated if the existing Thevenard oil and gas infrastructure were to be used to generate artificial reefs, including two reefing scenarios: i) leaving existing oil and gas structures in place or ii) removing structures and re-purposing parts of the material for new artificial reefs. It also has used the Exmouth Integrated Artificial Reef (EIAR), which was established in 2018, as an exemplar to evaluate the possible benefits that may arise from an artificial reef, constructed in part from oil and gas infrastructure. For both case studies, we applied two approaches: Approach 1 assumes new production of fish and new trips. Approach 2 assumes that all extra benefits are shared among the current population of users which increases trip demand. A limitation is the issue of needing to predict the future use of these new infrastructures, and the possible evolution of their ecological status under different levels of use.

For the Thevenard oil and gas infrastructure, we identified an overall annual economic benefit of \$189,943 to \$362,885 for approach 2 scenario 1 (leave in place) and \$23,224 to \$41,572 for approach 2 scenario 2 (use part of structures for developing an artificial reef) in the first year. The benefits included expenditures and consumer surplus measures for private recreational fishers. We also identified benefits for divers and charter boat operators. These results indicate that in the short term leaving Thevenard oil and gas infrastructure in place may result in higher economic benefits than repurposing parts of the structure as artificial reefs. This is mainly explained by the fact that the demand and the consumer surplus of recreational fishers depend on the catch rate and leaving the structures in place would preserve the marine life on the structure while a new artificial reef had to grow new fish populations. How exactly these values will evolve will depend on the growth on the new artificial reef and the fishing pressure on the structures. For example, a new artificial reef that is placed closer to shore can expect more recreational fishing activity than when structures are left in place. This might increase economic value in the short term but can also cause that the equilibrium is reached later. However, it is likely that the values presented may represent the bounds for potential values, and that the economic values associated with the two scenarios become more similar when fish communities reach an equilibrium in the long-term.

The analysis of potential economic benefits that the Thevenard oil and gas infrastructure could provide to commercial fisheries indicates that out of the 98 species that were documented around the existing structures, 40 have commercial and commercial/recreational value while 20 have aquarium fish value. Several of the species identified, most notably snappers and emperors are already well established species in the commercial market place. Just as with private recreational fishing and charter fishing there is clear potential to enhance the viability of commercial fishing. However, benefits ultimately depend on the impact that opening up the area has on the estimates of sustainable and allowed catch of each species. Hence, values will depend on the assessment of stocks in the area by species and estimation of the consequent impact on the sustainable harvests and allowable catch. Any recalibration of these measures will need to be built into future harvest strategies.

For the EIAR, the overall economic benefit expected from installation of the structures is \$269,882 under approach 1 (shift in demand) and \$1,318,000 under approach 2 (new production). These benefits included both expenditures and consumer surplus from recreational fishers.

In both case studies, the estimated increased value per fishing trip are relatively high compared to other studies, which arises from the relatively high level of fish stock identified on the structures compared to other natural reefs nearby (Harvey, unpublished data), the assumed relationship between increased biomass and catch rates, and the relatively high value placed on this fish species by fishers.

However, results from this report are likely underestimated for various reasons. Firstly, values are derived from only one element of the fishing experience, and exclude other values such as increased safety, that may arise from the location of the potential reef off Onslow and of the EIAR in the Exmouth Gulf than currently used fishing grounds.

Secondly, the study has included only limited information about values that may be associated with other user groups such as charter boat operators, recreational diving (i.e. non-extractive use) and commercial fisheries. Including economic benefits that artificial structures provide to these user groups would most probably increase total benefit estimates.

Moreover, due to a lack of information, land travel costs to arrive at boat ramps were not included in the calculations. Especially when visitors come from Perth, other Australian states or overseas, these costs might add significantly to the overall expenditures associated with the artificial structures.

The total economic value framework includes non-use values such as existence values which have not been estimated in this study. In the context of this work, existence values are values for marine man-made structures, or the assets associated with them without the person that holds these values actually using them. Therefore, these values can be held by anyone of the general public. A more complete assessment would therefore include surveys with the general public to identify what they would be WTP to achieve the improved ecological and economic outcomes associated with a new artificial reef.

Lastly, in the case of Thevenard infrastructure, current estimates assume one new artificial reef. However, it is not clear how many artificial reefs would be created. Given that there are nine oil and gas structures available, it is likely that more than one structure would be made available to users, therefore increasing the generated economic benefits. This is especially relevant when different structures are opened for different user groups such as recreational fishers, recreational divers and commercial fishers as this would create diverse economic benefits to a larger portion of the population.

However, the question of when there are diminishing returns to additional artificial reefs in the area needs to be considered if there is a large scale program put in place, at least from the perspective of use values. It is possible that existence values may be less affected by this. Moreover, some of these activities target the same resource and will compete with each other. This can mean that the level of use from the different user groups might be more restricted than estimated in this work. Also, overcrowding of a particular user group can diminish the value derived from these structures. This is especially important for extractive activities as they can decrease the fish biomass and therefore the economic returns on these structures. Hence, it is important that the role of the areas after the new structures are in place would have to be incorporated into adjusted harvest strategy documents where all activities would have to be managed within an appropriate management plan.

The applicability of predicted economic values will depend, from both an ecological and economic perspective, on the locations chosen for new reefs, as that will influence both the ecological “aggregation/production” and economic “additional/substitution” outcomes. From an ecological perspective, variability in reef fish abundance and biomass can be explained by the proximity to other artificial reefs, artificial reef design, and annual seasons (Strelcheck et al. 2005). Although these factors will have implications for economic values of the structures, to our knowledge there is no literature on the effects of the proximity to other artificial reefs on their economic values.

However, this is an area where the use of more complex models, that explicitly consider site choice by fishers in terms of expected catch and costs of undertaking trips (e.g. Random Utility Models of recreational fisher site choices) would provide additional insight, as they explicitly consider issues of site substitution and diminishing marginal utilities from additional sites, which will depend on spatial location. Economic data for the artificial reefs made out of Thevenard infrastructure as well as future studies from other locations are important to improve our understanding of these effects. This information would be very helpful to improve future decision making regarding the creation of new artificial reefs.

Given the lack of primary data that is specifically related to recreational site choice in this region, at an appropriate spatial scale, the approach has relied on benefit transfer i.e. taking values from the literature and applying them to this specific location, with assumptions about use derive from the limited available data. This introduces some uncertainty about the values that are attributed to the addition of the reefs. Specifically, the question of whether the reefs will generate new trips, or re-allocate existing trips, or the balance between the two, is important for evaluating aggregate value. Having region specific values for the value of improved recreational experience is also important, given the very wide range of values that are present in the data.

The study has included only limited information about values that may be associated with diving (i.e. non-extractive use). There are even fewer studies that can be used to identify values, and less data on use and expenditure in the region, but in principle the same analysis that is applied here to recreational fishing trips could be applied to diving. The issue of substitution v additional trips is also key here, as well as the possibility that the values associated with diving on artificial v natural reefs may differ, even if the species viewed are the same, adding an extra layer of complexity in the benefit transfer approach.

In the case of the EIAR, the improved catch from the reef was based on the preliminary surveys. Ecologically the reef had not yet reached an equilibrium state at the time of the surveys. Therefore, a higher level of productivity may be possible in the future than is currently seen. However, countering that, the fishing pressure will also not yet be at equilibrium, and one would expect that will provide a counterweight that will reduce fish populations.

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Appendix A

Table A.1: Artificial Reef Valuation Study Results

Study	AR Type(s)	Value Type(s)	Data Collection Year	Valuation Method(s)	Country	Valuation Context/Description	WTP (study units)	WTP (2019 USD)
Bell et al. (1998)	Shipwreck	Use - Direct		Market Non-Market	USA			
Börger et al. (2015)	Wind Turbines	Non-use (Existence) Use – Direct (Visual Amenity)	2013	Non-Market (DCE[1])	UK	Hypothetical windfarm in the Irish Sea between Anglesey and the Isle of Man <u>Attributes/levels</u>: 0, 10, 30 additional species to settle in and around the new offshore wind farm 180m (visible from Anglesey and the Isle of Man), 240m (visible from Anglesey, the Isle of Man and Cumbria), 300m (visible from Anglesey, the Isle of Man, Cumbria and Liverpool) high turbines Impact (cabling buried at 1m) No impact (cabling buried at 2m) of cables on marine mammals <u>Payment vehicle</u>: additional tax to be paid annually by every household to fund alternative windfarm design	£7.25-£12.91 per household per year (10 species) £14.83-£15.84 per household per year (30 species) No impact of wind turbine height/visibility on WTP £26.49 per household per year to prevent impact of cables on marine mammals	$10.79-$19.21 per household per year (10 species) $22.06-$23.56 per household per year (30 species) No impact of wind turbine height/visibility on WTP $30.11 per household per year to prevent impact of cables on marine mammals
Brandini et al. 2014	Concrete structures				Brazil			
Brock et al. 1994	Various Sunken Objects	Use – Direct (Recreation/Tourism, Commercial Fishing)	1990	Market	USA	Revenue associated with submarine/dive tourism and commercial fishing on Hawaiian ARs	$69.63/$63.02 pp per submarine tour/dive	$135.43/$122.57 pp per submarine tour/dive

Study	AR Type(s)	Value Type(s)	Data Collection Year	Valuation Method(s)	Country	Valuation Context/Description	WTP (study units)	WTP (2019 USD)
	(ship, concrete modules, aircraft)						$58,840 per year for commercial fishing (4% of net profit of dive tourism alone)	$114,439.52 per year for commercial fishing
Buchanan 1973		Use- Direct			USA			
Chen et al. 2013	Various Sunken Objects (ships, utility poles, steel and concrete structures)	Use – Direct (Recreation/Tourism)	2008	Non-Market (TCM[2] and CVM[3])	Taiwan	Travel costs associated with diving/recreational fishing trips in Penghu Survey question: *"How much did you actually pay (travel and other costs) to participate in scuba diving or recreational boat fishing?"* Willingness to pay for a ticket to visit an AR diving/recreational fishing zone in Penghu Survey question: *"If the government planned an AR scuba diving zone (or boat fishing zone) to improve the safety and facilities and to provide ocean weather conditions and other recreation information, how much would you be willing to pay for a ticket to participate in these activities?"*	$348.50/$281.91 per tourist per trip for diving/recreational fishing (TCM) $12.70/$13.00 per ticket for diving/recreational fishing (CVM)	$$411.46/$332.83 per tourist per trip for diving/recreational fishing (TCM) $14.99/$15.35 per ticket for diving/recreational fishing (CVM)
Christie et al. 2009	Sunken Sandbags (TerraFix mega geotextile)	Use – Direct (Visual Amenity, Recreation/Tourism)	Assume 2009 (not stated)	Non-Market (DCE)	UK	Coastal defence options for Borth in West Wales Attribute levels: no change (timber groynes), rock groynes, offshore reef Payment vehicle: annual increases in local tax over a five-year period	£98 per household per year (offshore reef excl. improved surf conditions) £171 per household per year (offshore reef incl. improved surf conditions)	$171 per household per year (offshore reef excl. improved surf conditions) $298 per household per year (offshore reef incl. improved surf conditions)

Study	AR Type(s)	Value Type(s)	Data Collection Year	Valuation Method(s)	Country	Valuation Context/Description	WTP (study units)	WTP (2019 USD)
Crabbe & McClanahan 2006	Sunken Ships	Use – Direct (Recreation/Tourism, Commercial Fishing)	2004	Market	Kenya	Revenue associated with commercial fishing and dive tourism	$9.00 increase per fisher per day at landing site for commercial fishing $75,000-$174000 per wreck per year in dive tourism	$12.00 increase per fisher per day at one landing site for commercial fishing $100,927-$234.151 per wreck per year in dive tourism
Ditton et al. (2001)	Various Sunken Objects (man-made materials, shipwrecks, oil and gas platforms)	Use – Direct (Recreation/Tourism)	1997	Market	USA	Revenue associated with commercial dive tourism	$162 pp per diving trip day for Texas residents $170 pp per diving trip day for Texas non-residents	$256.58 pp per diving trip day for Texas residents $270.67 pp per diving trip day for Texas residents
Dowling and Nichol (2001)	Sunken Ships	Use – Direction (Recreation/Tourism)	1999	Market	Australia	Revenue associated with commercial diver tourism and recreational fishing	$22.20 pp per day for private permit divers $35.35 pp per day for domestic group charter divers $41.10 pp per day for international group charter divers	$33.87 pp per day for private permit divers $53.94 pp per day for domestic group charter divers $62.71 pp per day for international group charter divers
Hannak et al. 2011	Snorkel trail	Non-use		Non-Market	Egypt			
Hicks et al. 2004	Oyster reef	Use-direct Non-use		Market Non-market	USA			
Hiett and Milon (2002)	Oil and Gas Platforms	Use – Direct (Recreation/Tourism)	1999	Market	USA	Revenue associated with commercial dive tourism and recreational fishing	$4691 per angler per year ($13 per angler per day)	$7157.63 per angler per year ($20 per angler per day)
Huth et al. (2015)	Shipwreck	Use-direct			USA			

Study	AR Type(s)	Value Type(s)	Data Collection Year	Valuation Method(s)	Country	Valuation Context/Description	WTP (study units)	WTP (2019 USD)
Islam et al. (2014)	Various Sunken Objects (ships, tyres, concrete objects/structures, oil and gas platforms)	Use – Direct (Artisanal fishing)	2011	Market	Malaysia	Revenue associated with commercial fishing (small-scale/artisanal)	$164 per fisher per month	$185.34 per fisher per month PPP
Johns et al. (2001)	Unspecified	Use – Direct (Recreation/Tourism)	2000	Market and Non-Market (CVM)	USA	Willingness to pay an extra amount in trip costs to maintain the AR in its existing condition Willingness to pay in annual boat registration/higher charter fees for an artificial reef program	$8.63 extra pp per day to maintain AR $75 pp per year for a program that maintains existing ARs $24 pp per year to create new ARs	$12.74 extra pp per day to maintain AR $110.12 pp per year for a program that maintains existing ARs $35.43 pp per year to create new ARs
Kasim et al. 2003	Concrete Structures	Use – Direct (Commercial fishing)	2007	Market	India	Net income from commercial fishing	INR1252 per unit operation per year for gillnet fisheries INR4650 per unit operation per year for hooks and line fisheries	$42.75 per unit operation per year for gillnet fisheries $158.77 per unit operation per year for hooks and line fisheries PPP
Kirkbride-Smith et al. (2016)	Sunken Ships	Use – Direct (Recreation/Tourism)	2013	Non-Market (CVM)	Barbados	Willingness to pay an extra amount in trip costs for recreation in the Folkestone Marine Reserve	$17.58 extra pp per day	$19.18 extra pp per day PPP
Leeworthy et al. 2006	Sunken Ships	Use – Direct (Recreation/Tourism)	1997	Market	USA	Revenue associated with recreational fishing and diving/snorkelling tourism	$2.6 million in total recreational expenditure	$4.12 million in total recreational expenditure
McGurrin and Fedler (1989)	Oil and Gas Platforms	Use – Direct (Recreation/Tourism)	1989	Non-Market (CVM)	USA	Willingness to pay for an additional AR	$14.36 pp one-off payment	$29.44 pp one-off payment
Milon (1988)	Sunken Ships	Use – Direct (Recreation/Tourism)	1985	Non-Market	USA	Benefits of a new centrally-located artificial reef site for private boat sport anglers	$1.80 pp per year	$4.28 pp per year

Study	AR Type(s)	Value Type(s)	Data Collection Year	Valuation Method(s)	Country	Valuation Context/Description	WTP (study units)	WTP (2019 USD)
				(TCM & NMNL)				
Morgan et al. (2009)	Sunken Ships	Use – Direct (Recreation/Tourism)	2006	Non-Market (TCM & CVM)	USA	Travel costs for divers to visit the USS Oriskany Divers' willingness to pay for an additional sunken ship	$480-$750 pp per trip to the Oriskany $220-$1160 pp per year for an additional ship	$605.24-$945.69 pp per trip to the Oriskany $277.40-1462.67 pp per year for an additional ship
Morgan et al. (2018)	Sunken Ships	Use – Direct (Recreation/Tourism)	2014	Non-Market (CVM)	USA	Willingness to pay an increased saltwater fishing license fee	$32.71 pp per year in additional license fee	$35.12 pp per year in additional license fee
Oh et al. (2008)	Unspecified	Use – Direct (Recreation/Tourism)	1997	Non-Market (CVM)	USA	Willingness to pay additional diving trip costs	$101 extra pp per year	$159.97 extra pp per year
Pendleton (2005)	Sunken Ships	Use – Direct (Recreation/Tourism)	2002	Market and Non-Market (TCM)	USA	Revenue associated with dive tourism Travel costs for divers to dive the Yukon artificial reef	$4.5 million in market contribution $1..2 million in non-market contribution ($110 pp per day)	$6.36 million in market contribution $1.70 million in non-market contribution ($156.62 pp per day)
Polak and Shashar (2013)	Concrete Structures	Use – Direct (Recreation/Tourism)	2010	Non-Market (CVM)	Israel	Willingness to pay to restore ARs (biological attributes coral size, coral diversity, fish abundance, coral abundance, a combination of numbers of fish and corals, and fish and coral biodiversity) using varying degrees of effort	NIS10-35 pp per year (low effort) NIS15-50 pp per year (medium effort) NIS25-70 pp per year (high effort)	$3.05-$10.67 pp per year (low effort) $4.57-$15.24 pp per year (medium effort) $7.62-$21.34 pp per year (high effort) PPP
Ramos et al. (2006)	Concrete Structures	Use – Direct (Commercial fishing)	2002	Market	Portugal	Net income associated with commercial fishing	€7858-€18896 per fisherman per year, depending on boat type	€11652.94-€28021.64 per fisherman per year, depending on boat type PPP

Study	AR Type(s)	Value Type(s)	Data Collection Year	Valuation Method(s)	Country	Valuation Context/Description	WTP (study units)	WTP (2019 USD)
Roberts et al. (1985)	Oil and Gas Platforms	Use - Direct (Recreation/Tourism)	1982	Non-Market (CVM)	USA	Willingness to pay for annual pass to dive under offshore oil and gas rigs	$163 pp per year	$429.38 pp per year
Sun et al. 2017	Concrete structure, rocks, shipwrecks	Direct-use			China			
Vivekanandan et al. (2009)	Various (concrete, and high-density polyethylene objects)	Use – Direct (Artisanal fishing))	2003	Market	India	Income associated with artisanal fishing	RS71.3 per hour of operation	$2.93 per hour of operation PPP
Westerberg et al. (2013)	Wind Turbines	Use – Direct (Recreation/Tourism Visual Amenity)	2010	Non-Market (DCE)	France	Additional cost of accommodation to have access to reef and wind farm associated recreational activities Attribute levels: no wind farm, wind farm 5km offshore, wind farm 8km offshore, wind farm 12km offshore Payment vehicle: change in weekly accommodation price	€39.60 pp per week (no wind farm) -€76.1 pp per week (5km offshore) €13.3 pp per week (8km offshore) €43.9 pp per week (12km offshore)	$50.04 pp per week (no wind farm) -$96.17 pp per week (5km offshore) $16.80 pp per week (8km offshore) $55.48 pp per week (12km offshore)
Whitmarsh et al. (2008)	Concrete Structures	Use – Direct (Artisanal fishing)	1990-2005	Market	Portugal	Value per unit effort associated with artisanal fishing	€13 extra per unit effort on AR sites compared to (non-reef?) control sites €0.18 increase per unit effort per month	$18.47 extra per unit effort on AR sites compared to (non-reef?) control sites $0.26 increase per unit effort per month
Wilhelmsson et al. (1998)	Various Sunken Objects (ships, dead coral heads)	Use – Direct (Recreation/Tourism)	1996	Market	Israel	Revenue associated with dive tourism excluding course dives and non-guided tours	$23 pp per dive $368,000 per year	$37.26 pp per dive $596,216.29 per year

[1]DCE=Discrete Choice Experiments; [2]TCM=Travel Cost Method; [3]CVM=Contingent Valuation Method

Table A.2: Studies that compare artificial reefs with natural reefs/non-artificial reef areas

Study	Key Findings	WTP (study units)	WTP (2019 USD)
Islam et al. (2014)	Income from artisanal fishing in Malaysia was significantly lower in AR areas, compared to "non-AR" areas	$164 per fisher per month in AR area $817 per fisher per month in non-AR area	$185.34 per fisher per month in AR area $923.39 per fisher per month in non-AR area
Johns et al. (2001)	Recreational value of NRs in South-East Florida was higher than ARs	$8.63 per person per day on ARs $12.74 per person per day on NRs	$12.74 per person per day on ARs $18.81 per person per day on NRs
Kasim et al. (2013)	Income from commercial fishing in India was higher in AR areas, compared to "non-AR" areas	INR1252 per unit operation per year for gillnet fisheries on ARs INR449 per unit operation per year for gillnet fisheries on NARs INR4650 per unit operation per year for hooks and line fisheries on ARs INR1919 per unit operation per year for hooks and line fisheries on NARs	$42.75 per unit operation per year for gillnet fisheries on ARs $15.33 per unit operation per year for gillnet fisheries on NARs $158.77 per unit operation per year for hooks and line fisheries on ARs $65.52 per unit operation per year for hooks and line fisheries on NARs PPP
Kirkbride-Smith et al. (2016)	Recreational value of NRs was higher than ARs in Barbados, but not significantly so	$17.58 extra per person per day for ARs $18.33 extra per person per day for NRs	$19.18 extra per person per day for ARs $20.00 extra per person per day for NRs PPP
Oh et al. (2008)	Recreational value of NRs was higher than ARs in Texas	$101 extra per person per year for ARs $171 extra per person per year for NRs	$159.97 extra per person per year for ARs $270.83 extra per person per year for NRs
Vivekanandan et al. (2009)	Income from commercial fishing in India was higher in AR areas, compared to "non-AR" areas	RS71.3 per hour of operation in AR areas RS52.5 per hour of operation in non-AR areas	$2.93 per hour of operation in AR areas $2.19 per hour of operation in non-AR areas PPP

Appendix B

The 2018 McLeod and Lindner study used a combination of surveys – a boat based study where the survey frame was fishers holding a valid recreational fishing boat license (RFBL) and a phone interview survey of anyone in a household in WA who could be contacted by any type of phone was initiated in 2016 to provide the necessary benchmark data. The comprehensive sampling frame for this survey was the Electronic White Pages (EWP) and allowed for the expenditure patterns of boat- and shore-based fishers in Western Australia to be assessed with and without an RFBL.

Information was collected on fishing activity, fishing location by bioregion, fishing platform, household composition and fishing expenditure across by major expenditure category. Effort was measured by days spent fishing for each household member. Mean shore fishing days per household was estimated to be 12.6 days, while mean boat fishing days was 10.77, so mean total fishing days per household was equal to 23.40. Of the 459 fishing households, around 26 percent fished only from a boat, 38 percent fished only from the shore and 36 percent fished from both shore and boat. Mean shore days per fisher was 6.76, mean boat days was 5.77, and mean total days per fisher was 12.53.

Only 27% of these 789 recreational fishers were what might be termed more avid fishers (i.e. fishers who fished 15 or more days per year), while a higher proportion (57%) were less avid fishers (i.e. fishers who fished less than 10 days per year). For WA, 357 (45%) recreational fishers fished only from a shore-based platform, while 189 (24%) fished only from boat-based platform, and 243 (31%) fished from both platforms during the year. Avidity varies across the fishing platforms. While some 57% of all WA recreational fishers were less avid, a much higher proportion (78%) of shore only recreational fishers were less avid. Conversely, less than half (47%) of boat only fishers were less avid, and only 37% of shore and boat fishers were less avid. Then again, the proportion of more avid fishers was highest among shore and boat fishers at 46%, followed by boat only fishers at 31%, while only 15% of shore only fishers were more avid.

Estimation of household expenditure by recreational fishers was subdivided into three main categories as follows:

- Trip related expenditures – incurred per trip by each fisher (e.g. fuel, bait, ice, food) plus resources spent to travel from place of residence to the boat launch site for boat-based fishing trips, or to the site on the shore for shore-based fishing trips. Trip related expenditures also includes accommodation costs for trips involving one or more overnight stays.
- Gear related expenditures - incurred annually by each fisher (e.g. rods, reels)
- Boat related expenditure - incurred annually for own boat use for recreational fishing (e.g. repairs, insurance, etc.) plus boat and charter hire.

The sample aggregate expenditure attributable to fishing households among the whole 1810 EWP sample households is representative of the fishing expenditure that would occur in all WA households. Hence aggregate expenditure by households in the sample can be scaled up to the estimated population of WA. A detailed breakdown of aggregate expenditure into component parts is provided in Table B.1 below.

Table B.1: Expenditure by category for recreational fishing in Western Australia

Expenditure item ($/year)	**Avg$/HH[a]**	**Avg$/fisher**	**Avg$/trip**	**Population $**
Expenditure on overnight accommodation	$171	$92	$7	$37,394,182
Expenditure on food, drink, refreshments	$2,775	$1,495	$120	$605,675,342
Expenditure on fuel for boat	$1,918	$1,033	$83	$418,546,256
Expenditure on parking and launching fees	$160	$86	$7	$34,968,170
Expenditure on bait and ice	$1,120	$604	$49	$244,539,414
Expenditure on other fishing trip costs	$189	$102	$8	$41,315,141
Expenditure on land travel	$2,186	$1,178	$95	$477,169,314
Aggregate trip expenditure				**$1,859,607,819**
Expenditure on rods, reels, pots, etc.	$561	$307	$24	$122,464,856
Expenditure on clothing (e.g. shoes, hats)	$63	$34	$3	$13,658,904
Expenditure on diving gear (incl. hire)	$87	$47	$4	$19,032,183
Expenditure on fishing club membership	$16	$9	$1	$3,574,312
Other gear related costs	$5	$3	$0	$1,160,624
Aggregate gear expenditure				**$159,890,879**
Expenditure on new boats	$537	$289	$23	$117,258,994
Expenditure on 2nd Hand Boats	$534	$288	$23	$116,531,293
Expenditure on Equipment (incl. hire)	$84	$45	$4	$18,307,306
Expenditure on repairs, maintenance	$332	$179	$14	$72,418,586
Expenditure on insurance	$115	$62	$5	$25,117,962
Expenditure on boat trailer licences	$53	$29	$2	$11,597,717
Expenditure on pen and club fees	$39	$21	$2	$8,404,255
Other boat related costs	$2	$1	$0	$448,073
Boat hire and charter fees	$87	$47	$4	$18,944,879
Aggregate boat expenditure				**$389,029,065**
Aggregate annual expenditure				**$2,408,527,764**

[a] HH = household

Expenditures are likely to vary by region of residence and region fished. Using data from the McLeod and Lindner (2018) study, Table B.2 below estimates per trip costs by bioregion fished. Exmouth is in the Geraldton Coast area and has the highest cost structure.

Table B.2: Per trip expenditures by bioregion

Region fished	**Food and drink**	**Fuel for boat**	**Parking and launch fees**	**Bait and ice**	**Other trip costs**
North Coast	$169.16	$147.15	$4.53	$45.04	$53.43
Geraldton Coast	$232.25	$290.64	$4.62	$69.22	$9.52
West Coast	$97.84	$110.16	$6.78	$36.61	$6.12
South Coast	$107.53	$96.34	$1.41	$45.72	$6.45
Total	$122.47	$134.44	$5.69	$42.48	$11.21

Gear costs are incurred per year rather than per trip. The Table B.3 estimates the annual gear costs for recreational fishers by region fished.

Table B.3: Annual gear costs by bioregion

Region Fished	Rods, reels, pots	Special clothing	Diving gear	Fishing club membership	Other gear costs
North Coast	$870.91	$157.79	$117.17	$49.80	$6.35
Geraldton Coast	$756.24	$78.98	$94.01	$24.68	$10.38
West Coast	$513.93	$51.65	$67.37	$25.51	$3.90
South Coast	$408.01	$45.11	$52.29	$11.82	$2.60
Total	$566.70	$64.67	$73.81	$26.23	$4.79

Annual boat related costs are shown below by region fished (Table B.4).

Table B.4: Annual boat costs by bioregion

Region fished	New boat	Second hand boat	Equipment other than boat	Repairs and maintenance	Insurances	Boat and trailer licence fees	Boat club membership	Other boat costs
North Coast	$2,663.31	$440.84	$627.76	$806.88	$352.68	$202.31	$23.89	$30.84
Geraldton Coast	$2,093.41	$1,185.41	$660.05	$1,110.78	$385.09	$162.87	$62.07	$29.28
West Coast	$1,772.39	$779.78	$550.72	$1,491.21	$388.01	$142.50	$160.12	$81.35
South Coast	$338.98	$855.93	$309.68	$1,229.78	$201.11	$177.38	$16.08	$1.63
Total	$1,756.49	$804.09	$547.59	$1,346.76	$364.86	$154.74	$119.11	$61.47

In order to access fishing opportunities in the Geraldton and North Coast regions, many fishers will incur accommodation costs. The nights away on a fishing trip and the average cost per night for accommodation are shown below (Table B.5) by fishing region.

Fishers in the Geraldton region incur cost of $137 for accommodation.

Table B.5: Accommodation costs by bioregion

Region fished	Nights away	Average accommodation cost per night
North Coast	6.93	$121.45
Geraldton Coast	12.30	$137.09
West Coast	6.46	$177.55
South Coast	9.25	$84.02
Total	7.92	$149.61

Appendix 5 The economic value of the Exmouth Navy Pier and Busselton Jetty, Western Australia

Johanna Zimmerhackel, Michael Burton

This appendix is part of the final report for:

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

Euan S. Harvey, Fran Ackermann, Michael Burton, Julian Clifton, Carmen Elrick-Barr, Johanna Zimmerhackel, Georgina Hill, Stephen J Newman, Jenny Shaw, Mark Pagano, Paul McLeod, Dianne McLean, Julian Partridge

24th August 2021

The Economic Value of the Exmouth Navy Pier and Busselton Jetty, Western Australia

Abstract

Piers and jetties are commonly used by recreational fishers and divers due to the marine life that aggregates around their pillars. We used an online travel cost survey to estimate the economic value in terms of expenditures and consumer surplus measures of two piers/jetties in Western Australia: The Exmouth Navy Pier and the Busselton Jetty. The Navy Pier was the second most important dive attraction in Exmouth for survey respondents and we estimate that it generates about $615,000 AUD in business revenues and $409,170 AUD in consumer surplus per year. We also found that the Busselton Jetty attracts approximately 535,115 visitors per year generating an annual expenditure of $6.4 million AUD and a consumer surplus of $19.26 million AUD per year. Results of this work highlight that piers and jetties have a high value for users in Western Australia and that more research is needed to better understand these values. Results also can be used in decision making processes regarding the management, maintenance, building and/or removal of piers and jetties in Western Australia.

1 Introduction

Piers and jetties are commonly used by recreational fishers as fishing platforms as well as by scuba divers due to the marine life that aggregates around the pillars of the structures. In Western Australia, there are about 1000 wharfs, piers and jetties along the coastline (See Appendix 1 of Harvey et al 2021). Also, recreational fishing and diving are popular activities and recreational fishing alone is estimated to generate an economic value of $2.4 billion AUD in Western Australia per year (McLeod & Lindner 2018). Consequently, it is likely that piers and jetties have a major social and economic value. However, to this date there is no study worldwide on the social or economic value of piers and jetties (there is ongoing work in South Australia on the social economic and historical significance of piers and jetties, but the report has not been released at this point: see https://yoursay.sa.gov.au/decisions/yoursay-engagements-sa-jetties-strategic-plan/background). Therefore, the aim of this work is to estimate the economic value associated with two piers and jetties in Western Australia: The Exmouth Navy Pier and the Busselton Jetty.

The Navy Pier is an active pier managed by the Australian Navy, located in a naval base 14 km away from Exmouth town, Western Australia. Although the pier is not open for public use, one local dive operator has the permission to use the pier for dive operations. The pier reaches 300 m into the Exmouth Gulf. The Navy Pier is rated as one of the best shore dives in Australia and the world. The rich marine life underneath the pier can be mainly explained by the well enforced no take area around the pier and very restricted access.

The Busselton Jetty is a 1.8 km long Jetty in Geographe Bay, Western Australia which is operated by a non-profit community organisation (Busselton Jetty Inc.). The Jetty runs a train, underwater observatory, interpretive centre and museum, underwater restaurant and undersea walk and scuba diving activities. The Jetty moreover can be used by recreational fishers and has a scuba diving platform about 1.7 km from the shore. Furthermore, the Busselton Jetty has a marine monitoring and research program and engages in marine education with local schools. The Busselton Jetty lies within the 'General Use Zone' of the Ngari Capes Marine Park. However, at the end of the Busselton Jetty, there is a sanctuary zone where fishing is not allowed.

We use two versions of the travel cost method to estimate both the expenditures that people incur to visit these sites as well as the users' personal welfare (measured as the consumer surplus) associated with a visit to the Navy Pier and Busselton Jetty. Results of this work give important information on the importance of piers and jetties that can be used in the decision making processes regarding the management, maintenance, building and/or removal of piers and jetties in Western Australia.

2 Methods

2.1 Survey Design and Distribution

2.1.1 Exmouth Navy Pier dive tourist survey

An online dive tourist survey was designed to understand the level of use as well as the expenditures associated with the Navy Pier. As there is only one diving company allowed to operate on the Navy Pier, the survey was distributed through the email system of this operator from May to September 2020. Additionally, in August and September 2020 flyers with the link to the online survey were distributed to dive tourists by the operator. Respondents were eligible for the survey if they were over 18 years old and had done diving activities in Exmouth in 2019 and/or 2020.

Section one of the survey asked respondents about demographic characteristics such as age, gender, location of residence and the number of dives (anywhere) done in 2019 and 2020 as well as in total. Diving was defined as "scuba diving, snorkelling and free diving for recreation (opposed to extractive activities)". Section two asked participants about their diving activities in Exmouth in 2019 and 2020. In particular, they were asked about the frequency and duration of visits to the Exmouth region (a visit being defined as "a period of one or more days spent in the Exmouth region (i.e. for holidays, visit friends or family, or for work"), as well as where they stayed and what their total expenditure for these visits were. Section three of the survey asked respondents to fill out a logbook where they indicated the dates, diving activities and diving related expenditures of each visit. Diving activities were given as a dropdown menu that included all of the main dive attractions (natural sites and marine infrastructure sites) in the region. The final section asked how many times people have visited the Navy Pier in their lives and what substitute activities they would do if the Navy Pier was not available for diving. For the full survey, see Appendix A.

2.1.2 Exmouth Navy Pier dive operator interview

The dive operator interview was done face to face via online conference and asked about visitor numbers to all attractions as well as specifically to the Navy Pier in 2019. It also asked questions regarding the contribution to the local economy in terms of operating, fixed and capital costs and well as expenditure on salaries and government fees.

2.1.3 Busselton Jetty survey

We designed an online survey for visitors of the Busselton Jetty to understand their frequency of visits as well as their expenditures associated with these visits. The survey was accessible between

May and August 2020 and was distributed from the Busselton Jetty staff through their social media channels and email newsletters. Due to the COVID-19 restrictions, this was the main distribution channel. However, in June 2020 visitors slowly started returning to the Busselton Jetty and we also distributed a link to the online survey via flyers that were given out at the entrance and in the museum of the Busselton Jetty. With the completion of the survey, respondents could opt in to participate in a prize draw to win $50 AUD.

The survey asked respondents about their demographic information such as age, gender and place of residence (via postcode). They then were asked about their frequency of visitation to the Jetty and people who stated zero were excluded from the following questions. We furthermore asked people about the purpose/intended activity for their current visit and how much they had spent for travelling to the Jetty as well as any other costs associated with that trip. Participants were asked what they would have done as an alternative if the Busselton Jetty was not closed. Lastly, they had the option to give comments on the content or quality of the survey. The full survey can be accessed in Appendix B.

2.2 Analysis

2.2.1 Travel Cost Method

The travel cost method is a revealed-preference method that is commonly used to measure the economic use value associated with a single recreational site (Ward et al. 1986). The method is based on the notion that visitors bear different travel costs to stay at a recreation site and that the number of trips made to this site depends on these costs. The relationship between the number of trips and the travel costs describes the demand curve which in turn reveals the consumer surplus (a monetary measure of the benefits to users) of that recreation site (Ward et al. 1986).

2.2.2 Navy Pier: Zonal Travel Cost Model

The zonal travel cost method is typically used to estimate the value for recreational services of a single site. It is used to calculate the number of visits to the site assuming that travel costs to the site increase with distance. Respondents are combined into a number of zones (geographic areas) with increasing distance around the site. In this study, we calculated the total number of days spent in the Ningaloo region from dive tourists coming from six zones (in the order of increasing distance): Western Australia, other states of Australia, Oceania, Asia, Europe and America. The visitation rate was obtained based on days spent in the Exmouth region per million capita of the total population of countries where visitors came from in each zone.

The travel costs were estimated as the product of the global average of airflight costs per 100 km (ref) and the travel distance. For travellers coming from outside Australia, it was assumed that they departed from the capital city of their country of origin and travelled through Perth to get to Exmouth, Western Australia. Similarly, for travellers from Australia, we used the distance from the capital city of the Australian state to Perth and added the distance from Perth to Exmouth. For travellers from Western Australia, we only used the distance from Perth to Exmouth. We fitted the following regression analysis to the data:

$$\ln(stay) = a + {}^{1}/_{TC} * b \qquad (1)$$

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 *a* and *b* are model parameters.

We then used the predicted model to estimate how the demand (the number of days spent) for the Ningaloo region would change if travel costs increased in order to estimate the economic benefit (consumer surplus) that the Ningaloo region provides to visitors. The increase in travel costs was based on a hypothetical entrance fee that visitors had to pay per day to enter the Exmouth region.

2.2.3 Busselton Jetty: Individual Travel Cost Method

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 a number of issues that have to be addressed. The Poisson model is well known to impose restrictions on the distribution of the data. This model holds the assumption that the conditional mean and variance of the dependent variable is equal (also called equidispersion), which may not be the case. An extension to the model in form of a negative binomial model allows for over dispersion. Secondly, if data is collected from intercept sampling, then by definition the number of visits has to be more than one. However, it is possible to deal 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 α, the estimated cost coefficient (-1/α).

The other issue is the definition of cost of travel to the site. The sample has limited information on travel cost, other than that which can be derived from information about the postcode from which they live. We start by calculating the direct travel cost from the centroid of the postcode they give as their home, to the centroid of the 6280 postcode area. For those who lived outside of 6280, an additional 10 km was added to reflect the distance from the centroid to the jetty. For those who lived within 6280 this was reduced to 0.5 km, on the assumption that the majority of respondent lived in the city, not the surrounding area. Then an adjustment was made for the cost per person, based on the number of people in the group.

3 Results and Discussion

3.1 Exmouth Navy Pier

3.1.1 Descriptive statistics

The online survey resulted in a total of 153 valid responses. Respondent characteristics are shown in Table 1. Over one third of visitors come from Western Australia, followed by Europeans and other states of Australia from where each about one quarter of respondents come from. The average number of visits to the region per year is relatively high (1.95), which can be explained by a high visitation rate from Western Australians. The dive operator interview revealed that approximately 3000 divers visit the Navy Pier per year. With an average expenditure for one day diving in the Exmouth region of AUD 205, this gives an aggregate annual expenditure of AUD 615,000.

Table 1: Respondents' characteristics (n=153).

Respondents' characteristics	Value	Range
Average age (years)	39 (SD 12.17)	22-72
Gender (% female)	45.39	
Origin (%)		
Western Australia	36.84	
Other states of Australia	23.68	
Oceania	0.66	
Asia	2.63	
Europe	25.66	
America	10.53	
Avidity scuba diving		
Average number of dives in last 12 months	24.71	5-250
Average number of dives in life	123.05	5-500
Avidity snorkelling		
Average number of snorkelling in last 12 months	21.08	5-250
Average number of snorkelling in life	138.93	5-500
Average number of trips (# of trips/year)	1.95 (SD 4.37)	1-50
Average trip duration (# of days/trip)	8.00 (SD 9.90)	2-90
Average number of days spent diving or snorkelling		
Average total trip expenditure (AUD)	2410.66 (SD 2085.59)	150-15000
Average expenditure on diving (AUD/day)	205	

When respondents were asked what they would do if the Navy Pier was not available for diving, 62.22% said that they would dive at another dive site in Exmouth instead. Doing non-diving activities in Exmouth or diving at a dive site outside Exmouth was selected by 13.3% each. 6.67% stated they would do non-diving activities somewhere else and 4.44% said that they would stay at home if the Navy Pier was not available. Hence, it can be argued that the Exmouth region could lose up to a quarter of their dive tourists if the Navy Pier was not open to diving. Moreover, for 27% of the sample the Navy Pier was the second most visited dive attraction in the Exmouth region (Figure 1).

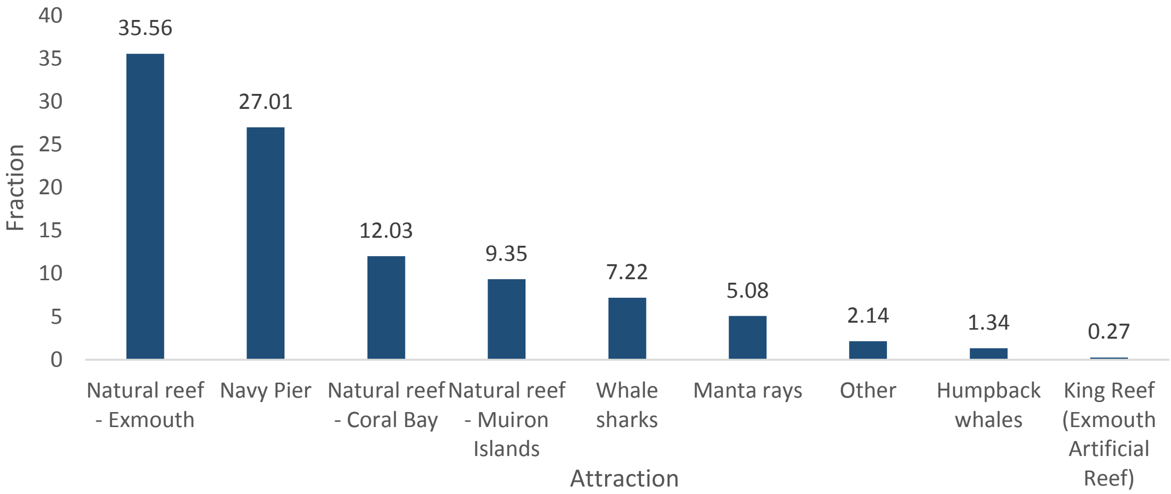

Figure 1: Percentage that respondents visited different dive attractions in the Exmouth region.

3.1.2 Zonal Travel Cost Model

The travel cost model results (Table 2) show the relationship between the costs of getting to the region and the per capita visitation rate. Based on this equation, we extrapolate how aggregate visitation would change for (simulated) increases in price, which is essentially deriving the demand curve for diving in the Exmouth region. We assume 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) at which demand would fall to zero. This is approximately double the amount of travel costs from the zone with the highest cost (America) (Cohen et al. 2016). This approach leads to a segmented aggregate demand curve, as shown in Figure 2, where 'kinks' occur as segments leave the market entirely. The area under the demand curve represents the consumer surplus of our sample that arises from the 1779 trip days. 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, not only the Navy Pier. If we assume this value also applies to dives at the Navy Pier, with approximately 3000 divers visiting the Navy Pier per year, this gives an aggregate consumer surplus of $409,170 AUD per year.

Table 2: 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		

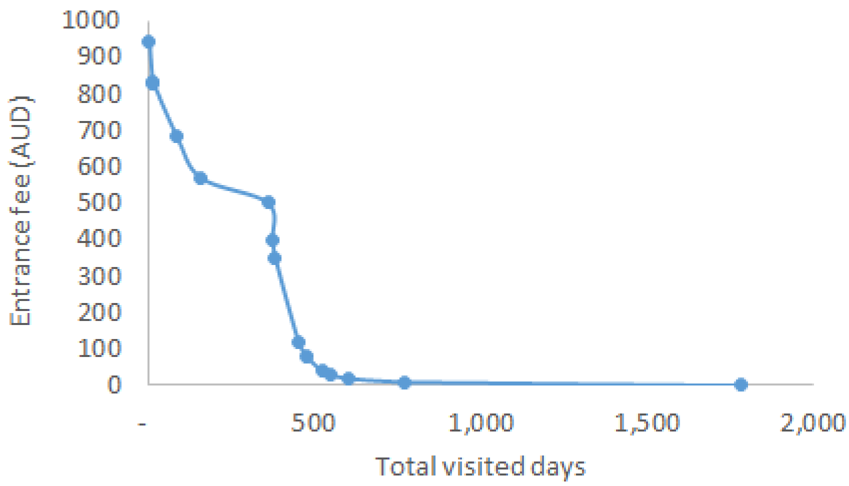

Figure 2: Demand curve for diving in the Exmouth region.

3.2 Busselton Jetty

3.2.1 Descriptive statistics

The individual travel cost survey yielded a total of 228 responses out of which 17 were excluded from the analysis because they had a postcode outside Western Australia. Hence, we obtained 211 usable responses who gave information on their total number of trips to Busselton Jetty in 2019. Just over half the respondents (51%) were resident in Busselton and 41% were male. The median number of trips that respondents made to the Busselton Jetty in that year was eight, although a significant proportion (14%) said they went more than 50 times in the year (Figure 3). The survey also revealed that the median expenditure associated with one visit on the Busselton Jetty per person is $12 AUD.

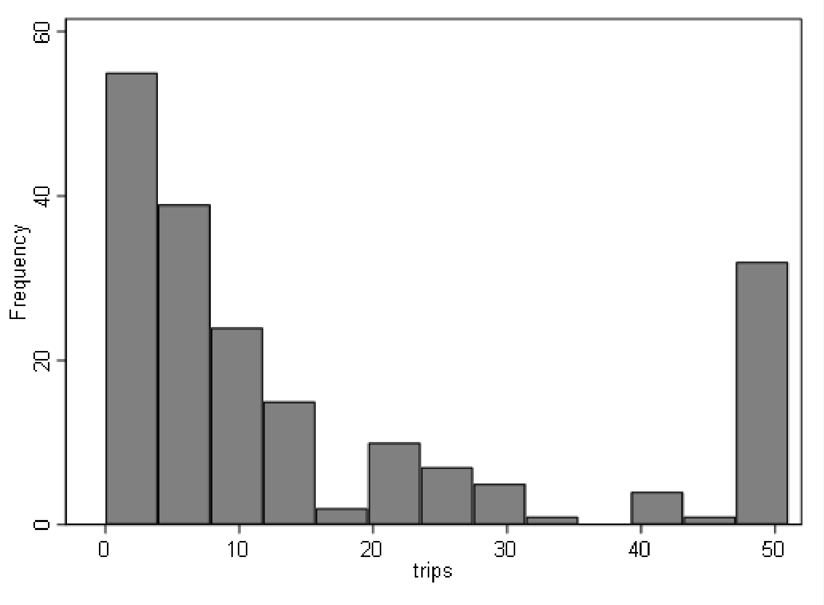

Figure 3: Frequency of visits to the Busselton Jetty in 2019 (n=195)

Of the 93 who responded to the question: "During your last visit to the Busselton jetty, was going to the jetty the main reason for your visit to Busselton", 44% said yes, and 32% said it was one of the reasons. However, this question was obviously not relevant for those who live in Busselton. Figure 4 below gives the main reasons for their last visit to the Jetty.

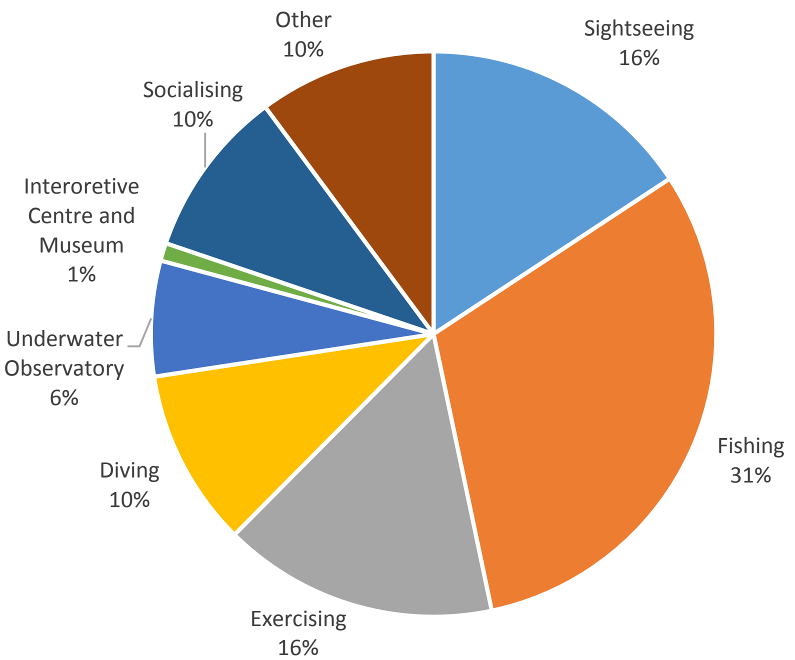

Figure 4: Fraction of reasons that respondents visited the Busselton Jetty.

Respondents were also asked what they would have done if the Busselton Jetty had been closed, i.e. to what extent are there substitutes for the experience. The set of options was limited, and did not enquire about details of other activities. A relatively small proportion (14%) would have gone out for any activity, but 39% would have looked for the same activity elsewhere, suggesting the high degree of specificity about the values being derived from the jetty. 32% would have still come to Busselton, but looked for a different activity. About 15% of respondents said they would have stayed at home if they could not have visited the Busselton Jetty. This highlights the importance to Busselton of the jetty for attracting these cohorts.

3.2.2 Individual Travel Cost Model

Using a censored negative binomial model, we find a significant negative relationship between the travel costs of getting from their place of residence to the Busselton Jetty, as reported in Table 3. Based on the results of this model, we estimated the consumer surplus for one visit on the Busselton Jetty to be $36 AUD. The Busselton Jetty attracts approximately 535,115 visitors per year (data from Busselton Jetty ltd). Accordingly, the consumer surplus generated by the Busselton Jetty for visitors is estimated to be $19.26 million AUD per year. Aggregating the median visitors' ***expenditure*** over that population, we estimate that an annual expenditure of $6.4 million AUD in 2019 can be attributed to the pier. Note that in this case the estimates of the surplus value (that attained by the user) is substantially greater than the expenditure estimate which reflects a low cost to visit the Busselton Jetty compared to the welfare that visitors receive from the visit. The result also is relatively high compared to consumer surplus values of a trip to e.g. a WA beach. This can probably be explained by the low number of substitute sites of the Busselton Jetty compared to other attractions in the region.

Table 3: 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		

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Appendix A: FRDC Navy Pier- Dive Tourist Survey

Participant Information Form

Thank you for your interest in this survey which examines the economic value associated with man-made aquatic structures.
Structures such as piers and jetties are playing an increasing role in shaping the diving landscape. In order to plot the future direction and potential development of these structures, a better understanding is needed of the economic value these structures provide the community. Your participation in this survey will help develop a clearer understanding of how divers are using these structures and their importance as assets for communities.
At the end of this survey, you will have the option to enter a second survey which will ask you about your social values towards artificial structures in the marine environment. Full details of the research are available at http://www.frdc.com.au/project/2018-053

Confidentiality and completing the survey

Taking part in a research project is voluntary. Should you change your mind at any point in the survey before submitting it, you can withdraw from the project. Any information we collect will be treated as confidential and all data collected is anonymous. The results of this research may be presented at conferences or published in professional journals. You will not be identified or be identifiable in any results that are published or presented. The survey should take no more than ten minutes to complete.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2019-0465). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au

By continuing with the survey, you agree with the following statement: "I have received information regarding this research and have had an opportunity to ask questions. I believe I understand the purpose, extent and possible risks of my involvement in this project and I voluntarily consent to take part."

The prize-draw

Upon completion of the survey, you will be invited to take part in a prize draw with the chance to win one of three $50 Coles gift cards. If you opt in to participate in the second survey, you will be entered twice into the prize draw which doubles your chances to win.

1) Winners will be chosen by selecting three random entrants. This selection will be undertaken by the Chair of the Research Project Steering Committee who will not be permitted to enter the survey. This selection will

be witnessed by two other members of the Steering Committee, who will also not be permitted to enter the survey.

2) Prize winners will be contacted by the researchers via email and/or phone within 48 hours of the prize draw. Verbal confirmation of age will be requested to ensure that the recipient is aged 18 or over as required by the online survey. Recipients will not be identified or identifiable publically. Only the postcode of the three winners will be published on the FRDC website.

3) Should any prize winner not be able to be contacted within one week of the draw, the above procedure will be repeated until all three prizes are claimed.

- o I agree

Block: Demographics

You have been asked to complete this survey because you are in the email list of a dive operator in Exmouth.

Have you done any dive activities in the Exmouth Region in 2019 or 2020? By diving we mean scuba diving, snorkelling and free diving for recreation (opposed to extractive activities).

- O Yes
- O No

Q1 Please indicate your age

▼ Under 18 ... Over 75

Q2 Please indicate your gender

- O Male
- O Female
- O Other/ prefer not to say

Q3 Where do you live?

O Exmouth region (as on map)

O Elsewhere in Australia

O Other country (please indicate) ____

Display This Question:

If Where do you live? = Elsewhere in Australia

Q4 Please type the postcode of your place of usual residence

____

Display This Question:

If Where do you live? = Exmouth region (as on map)

Q5 Where do you live in the Exmouth region?

O Exmouth town

O Coral Bay

O Onslow

O Other (please specify) ____

Block: Not eligible - link to second survey

Q6 Thank you for your time, you are not eligible for this survey.
However, there is a second survey which asks about more general information about other man made marine infrastructure. If you would like to complete this survey, select 'Yes' below. If you complete that survey you will be given an entry into the draw to win one of three $50 Coles gift cards.

O Yes

O No

Block: General Diving Questions

Q7 We are going to ask you about your diving experience in general. By diving we mean scuba diving, snorkelling and free diving for recreation (opposed to extractive activities).

Q8 In total, how many times have you gone diving?

	Ever	In 2019 and 2020
Scuba diving	▼ 0 ... 500 and more	▼ 0 ... 500 and more
Snorkelling and free diving	▼ 0 ... 500 and more	▼ 0 ... 500 and more

Block: Exmouth Diving - Non-residents

Q9
The following questions will ask you about your visit(s) to the Exmouth region (as shown on map). A "visit" is defined as a period of one or more days spent in the Exmouth region (i.e. for holidays, visit friends or family, or for work).

Q10 How many visits have you made to the Exmouth region in which you went diving, in 2019 and 2020?

▼ 1 ... More than 50 times

Q11 Where were you staying in the Exmouth region during the most recent visit?

O Onslow town

O Exmouth town

O Coral Bay town

O Campground outside of towns (please specify)
____

O Other (please specify) ____

Q12 How many days were you staying in the Exmouth region during the most recent visit?

____

Q13 What do you think the total cost was for that visit (including travel, accommodation, dive activities, fees, food, drink, and other costs)?

____

Q14 Please tell us about your dive activities during the most recent visit.

	Date	Dive activity	Expenditure on the dive activity (including fees, boat fuel and any other costs related to the dive)
	(dd/mm/yyyy)		(AUD)
Activity 1		▼ Whale shark tour ... Other	
Activity 2		▼ Whale shark tour ... Other	
Activity 3		▼ Whale shark tour ... Other	
...			
Activity 15		▼ Whale shark tour ... Other	

Q15 How many times have you dived the Navy Pier in total (including all visits ever made)?

▼ 0 ... More than 5

Display This Question:

If Please tell us about your dive activities during the most recent visit. : Dive activity = Navy Pier

Q16 If the Navy Pier was not available for diving activities, what would you have done instead?

- O Dive at another dive site in Exmouth
- O Do non-diving activities in Exmouth
- O Dive at another dive site somewhere else
- O Do non-diving activities somewhere else
- O Stay at home

Block: Exmouth Diving - Residents

Q17 How many times have you done dive activities in the Exmouth region in 2019 and 2020?

▼ 1 ... More than 15

Q18 Please tell us about your dive activities in 2019 and 2020.

	Date	Dive activity	Expenditure on the dive activity (including fees, boat fuel and any other costs related to the dive)
	(dd/mm/yyyy)		(AUD)
Activity 1		▼ Whale shark tour ... Other	
Activity 2		▼ Whale shark tour ... Other	
Activity 3		▼ Whale shark tour ... Other	
...			
Activity 15		▼ Whale shark tour ... Other	

Q19 How many times have you dived the Navy Pier in total?

▼ 0 ... More than 5

Display This Question:

If Please tell us about your dive activities during the most recent visit. : Dive activity = Navy Pier

Q20 If the Navy Pier was not available for diving activities, what would you have done instead?

O Dive at another dive site in Exmouth

O Do non-diving activities in Exmouth

O Dive at another dive site somewhere else

O Do non-diving activities somewhere else

O Stay at home

Block: Comments

Q21 Do you have any other comments you would like to make?

____

Q22 Thank you!
If you would like to be entered into the prize draw for one of three $50 Coles gift cards, please enter your email address and mobile number below. Multiple survey entries from the same individual or from respondents outside of Australia will not be eligible for the prize draw.

We will only use this information to contact you if you are selected in the prize draw.

Email address: ____

Phone number: ____

Q23 Would you like to continue to the second survey on the social values of marine man-made structures?

If you proceed, you will double your chances to win one of three $50 Coles gift cards.

O Yes

O No

Appendix B: Busselton Jetty Individual Travel Cost Survey

Participant Information Form

Thank you for your interest in this survey which examines economic value associated with man-made aquatic structures. Structures such as piers and jetties are playing an increasing role in shaping the recreation landscape. In order to plot the future direction and potential development of these structures, a better understanding is needed of the economic value these structures provide the community. Your participation in this survey will help develop a clearer understanding of how people are using these structures and their importance as assets for communities.

Full details of the research are available at http://www.frdc.com.au/project/2018-053

Confidentiality and completing the survey

Taking part in a research project is voluntary. Should you change your mind at any point in the survey before submitting it, you can withdraw from the project. Any information we collect will be treated as confidential and all data collected is anonymous. The results of this research may be presented at conferences or published in professional journals. You will not be identified or be identifiable in any results that are published or presented. The survey should take no more than ten minutes to complete.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2019-0465). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au

By continuing with the survey, you agree with the following statement: "I have received information regarding this research and have had an opportunity to ask questions. I believe I understand the purpose, extent and possible risks of my involvement in this project and I voluntarily consent to take part."

The prize-draw

Upon completion of the survey, you will be invited to take part in a prize draw with the chance to win one of three $50 Coles gift cards.

1) Winners will be chosen by selecting three random entrants. This selection will be undertaken by the Chair of the Research Project Steering Committee who will not be permitted to enter the survey. This selection will be witnessed by two other members of the Steering Committee, who will also not be permitted to enter the survey.

2) Prize winners will be contacted by the researchers via email and/or phone within 48 hours of the prize draw. Verbal confirmation of age will be requested to ensure that the recipient is aged 18 or over as required by the online survey. Recipients will not be identified or identifiable publically. Only the postcode of the three winners will be published on the FRDC website.

3) Should any prize winner not be able to be contacted within one week of the draw, the above procedure will be repeated until all three prizes are claimed.

- o I agree

Block: Demographics

APPENDIX B

Q1 Please indicate your age

- O under 18
- O 18 - 19
- O 20 - 24
- O 25 - 29
- O 30 - 34
- O 35 - 39
- O 40 - 44
- O 45 - 49
- O 50 - 54
- O 55 - 59
- O 60 - 64
- O 65 - 69
- O 70 - 74
- O Over 75

APPENDIX B

Q2 Please indicate your gender

O Male

O Female

O Other / prefer not to say

Q3 Are you a resident of Busselton?

O Yes

O No

Q4 Please indicate the postcode of your usual residence

____

Block: Trips

Q5 How often have you visited the Busselton Jetty in 2019?

O 0

O 1

O 2

O …

O 50

O More than 50 times

Block: Not eligible, link to mapping survey

APPENDIX B

Display This Question:

If How often have you visited the Busselton Jetty in 2019? = 0

Q6 Thank you for your time, you are not eligible for this survey. However, there is a second survey which asks you more general information about other man made marine infrastructure. If you would like to complete this survey, select 'Yes' below. If you complete that survey you will be given an entry into the draw to win one of three $50 Coles gift cards.

O Yes

O No

Block: Activities

Display This Question:

If Are you a resident of Busselton? = No

Q7 During your last visit to the Busselton Jetty, was going to the Jetty the main reason for your visit to Busselton?

O Yes

O No

O It was one of the reasons

APPENDIX B

Q8 What was the main reason for your last visit to Busselton Jetty?

O Sightseeing

O Fishing

O Exercising

O Diving

O Underwater Observatory

O Interpretive Centre and Museum

O Socialising

O Underwater dining

O Other (please indicate) ____

Q9 How many people were in your group during your last visit to the Busselton Jetty?

O 1

O 2

O …

O 20

O More than 20

Display This Question:

If How many people were in your group during your last visit to the Busselton Jetty? = 1

Q10 Apart from the costs of getting to the Busselton Jetty, what has been your expenditure (in AUD), associated with the visit to Busselton Jetty (food, drink, bait, entrance fees, etc.)

____

Display This Question:

If How many people were in your group during your last visit to the Busselton Jetty? != 1

Q11 Apart from the costs of getting to the Busselton Jetty, what has been the expenditure (in AUD) of your group, associated with the visit to Busselton Jetty (food, drink, bait, entrance fees, etc.)

____

Q12 If for some reason the Jetty was closed, what would you have done instead?

- O Another activity in Busselton
- O The same activity somewhere else
- O Another activity somewhere else
- O Stayed home

Block: Comments

Q13 Do you have any other comments you would like to make?

____

Block: Prize Draw

APPENDIX B

Q14 Thank you!
If you would like to be entered into the prize draw for one of three $50 Coles gift cards, please enter your email address and mobile number below. Multiple survey entries from the same individual or from respondents outside of Australia will not be eligible for the prize draw.
We will only use this information to contact you if you are selected in the prize draw.

Email address: ____

Phone number: ____

Block: Eligible, link to mapping survey

Q15 There is a second survey which asks you more general information about other man made marine infrastructure. If you would like to complete this survey, select 'Yes' below. If you complete that survey you will be given a second entry into the draw to win one of three $50 Coles gift cards.

O Yes

O No

Appendix 6 The use of man-made marine structures in Western Australia: A random utility model

Johanna Zimmerhackel & Michael Burton

This appendix is part of the final report for:

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

Euan S. Harvey, Fran Ackermann, Michael Burton, Julian Clifton, Carmen Elrick-Barr, Johanna Zimmerhackel, Georgina Hill, Stephen J Newman, Jenny Shaw, Mark Pagano, Paul McLeod, Dianne McLean, Julian Partridge

24th August 2021

FRDC Project No **2018-053**

The use of man-made marine structures in Western Australia: A random utility model

1 Abstract

Man-made marine structures (MMS) attract significant marine life which creates socio-economic impact for a range of users such as commercial and recreational fishers, and divers. This work (i) analyses to what extent MMS influence the site choice and (ii) estimates the economic value of MMS using a multiple site choice model of boat-based recreational fishing and diving activities in four regions in Western Australia: Geographe Bay, Coral Bay, Exmouth and Onslow.

Results show that artificial reefs and jetties positively influence recreational fishers' site choice. Similarly, jetties and shipwrecks significantly influence divers' site choice. In Geographe Bay, recreational fishers valued most the Dunsborough Artificial Reef, followed by the Busselton Jetty whereas divers valued the HMAS Swan wreck the most, followed by the Busselton Jetty and the FV Lena wreck. We also found that a hypothetical new MMS in Geographe Bay was valued more the closer to a boat ramp it would be built. This was confirmed in the Onslow region, where we estimated the value of re-purposing nine oil and gas structures into artificial reefs accessible for recreational fishers or divers. We found that converting the two structures the closest to the boat ramp generated almost half of the value compared to converting all nine structures. The results of this work can inform decision-making processes of existing and prospective MMS in Western Australia.

2 Introduction

Man-made marine structures (MMS) attract significant marine life which creates socio-economic impact for a range of users such as commercial and recreational fishers, and divers. In Western Australia, there are an estimated 7200 MMS including shipwrecks, piers and jetties, purpose built artificial reefs and oil and gas infrastructure (Harvey et al 2021, Appendix 1) . However, there is limited information on the socio-economic impact of MMS globally, and (to the best of our knowledge) only two studies on the economic value of MMS in Australia.

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. Rogers et al. (2018) did a benefit-cost-analysis for an oyster reef restoration project in South Australia. They estimated that the project would demonstrate a two and four return on investment and generated net benefits between AUD 4 million and AUD 10 million.

However, these estimates are based on single sites and do not take the substitution activities of users from/to other MMS and other natural sites into consideration. This is important because users have a whole range of options of sites they could visit. Hence, removing or adding a MMS at a site will likely result in users reallocating their activities within the region. Therefore users do not lose or gain the benefits of the entire trip to the MMS, but the difference in value between the first choice and the second choice site.

This work will address these gaps by using a multiple site choice model of boat-based recreational fishers and divers in four regions in Western Australia that contain a variety of MMS: Geographe Bay, Coral Bay, Exmouth and Onslow. The objectives of this work are to

- analyse to what extent MMS influence the site choice of recreational fishers and divers in Western Australia
- estimate the economic value of MMS for recreational fishers and in Western Australia, where users can substitute with other sites within the region

The results of this work can inform decision-making processes of existing and prospective MMS in Western Australia.

3 Methods

3.1 Survey

We used an online survey with recreational fishers and divers that was distributed on various channels:

- Recfishwest monthly 'Broadcast' newsletter between December 2019 and January 2020
- Recfishwest Facebook page and Instagram posts between December 2019 and February 2020
- 500 flyers and 100 posters mailed to 40 dive and tackle shops across all four WA fishing regions in January 2020
- Link from two online travel cost surveys conducted by this research team at the Busselton Jetty and the Navy Pier between May and September 2020

In the first three distribution channels, respondents first completed a survey on their social values of MMS (not part of this report) and were then directed to the site choice survey. By finishing these surveys, they had the option to participate in a prize draw to win AUD 750. Respondents that participated coming from the other two online travel cost surveys could partake in a prize draw for AUD 50. The difference in rewards reflects the differing sizes of the combined surveys being completed.

The social survey asked participants whether they would classify themselves as either recreational fishers, divers or neither. The neither group was not forwarded to the site choice survey while the recreational fishers and divers were asked to only give information about the activity that they classified themselves as.

Respondents were 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 give information about up to five day trips in the region. The information included on-the-water travel distance, travel costs to arrive at the destination, other costs associated with trips and factors that determine the quality of the sites (e.g., target fish species). For each day trip, they were then presented with the map of the region where they could indicate up to three locations that they were fishing or diving at on that particular day. The survey also collected information about the place of residence, age and gender of respondents. The full survey can be accessed in Appendix A.

3.2 Random Utility Model

This work used a Random Utility Model (RUM) to analyse to what extent MMS influence the site choice of recreational fishers in Western Australia. This model assumes that each user *i* selects a site *j* that maximises the expected utility U_{ij}:

$$U_{ij} = \beta' x_{ij} + e_{ij} \tag{1}$$

Where x_{ij} are the observed characteristics of each site option, β are the coefficients of these characteristics and e_{ij} is the error term. Assuming that the errors are independent and identically distributed (iid) extreme values, the probability that a site is selected can be expressed by the conditional logit formula:

$$prob_{ij} = \exp(\beta' x_{ij}) \Big/ \sum_{k=1}^{K} \exp(\beta' x_{ik}) \tag{2}$$

The advantage of this approach is that RUMs can not only test how site specific (and individual specific) factors influence their recreational fishing site choice, they can also estimate the monetary value of these effects. Moreover, this method allows one to predict the economic consequences of future scenarios (such as the removal or addition of MMS) for recreational users by simulating site choice under the new scenario.

As respondents could choose up to three locations on each map, we used only those responses where either only one location was selected or where all selected locations were situated within the same grid cell.

3.2.1 Variables

The dependent variable is the recreational site choice where each choice option is one cell on a map of the according regions divided into a grid of 10 x 10 nm (Figure 1). The limit of the grid was determined by the extent of the map shown to respondents in the survey.

We tested a range of site specific factors such as the on the water travel cost which was calculated as the costs for a return trip from the nearest boat ramp to the fishing or diving location times the fuel costs. Fuel costs were estimated to be AUD 0.56 per km travelled (Navarro et al. 2018). On the water travel costs to all grid cells the respondent did not choose were based on the distance from the boat ramp the respondent left from to the centre of each grid cell.

We also tested whether the presence of a MMS in a certain grid cell has a significant influence on the site choice of fishers. 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 in the study regions were mainly designed for recreational fishing activities and are mainly used by them. However, they are open to divers.
- Piers and jetties were represented by the Busselton Jetty which is open to both recreational fishing and diving, except for a sanctuary zone that is only open to diving.

As Thevenard O&G infrastructure are closed to any recreational activity, we could not measure the values associated with this structure type. In the Exmouth region, we did not consider the Navy Pier in the scenarios because it is closed to boat-based activities.

A limitation of the mapping process is the accuracy to which respondents could identify where they had gone when placing a marker on the map. Some respondents explicitly noted that they had visited the MMS. Using this subset of respondents, we evaluated the distance from the MMS and where they placed their marker, and the maximum distance in the set, and used this as a measure of accuracy. We then defined someone to have visited a MMS by drawing a buffer zone around each MMS where the size of this zone was determined by the maximum distance.

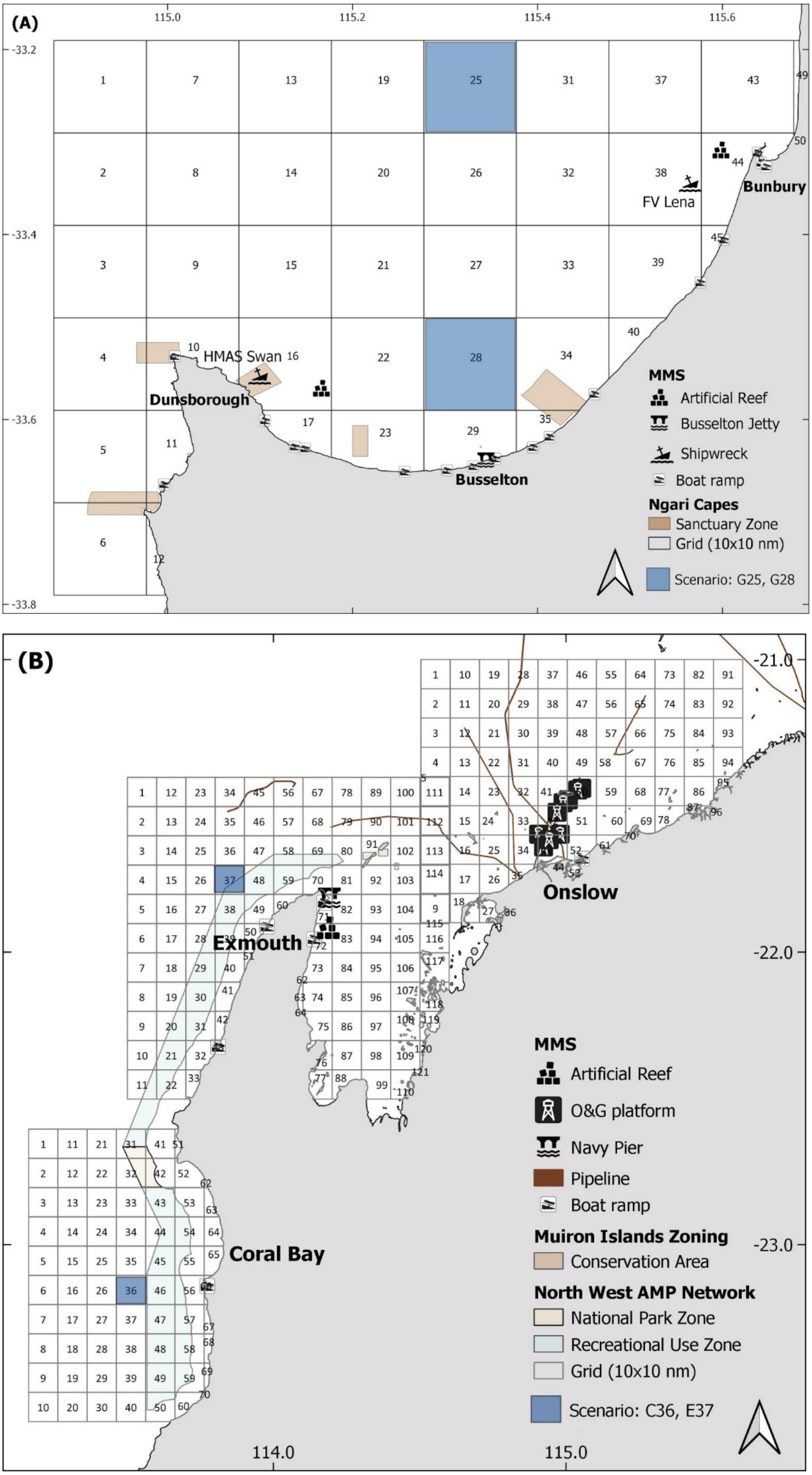
Environmental site specific factors that could influence recreational fishers' site choice were added to the model as the mean water depth (m) of each grid cell. Due to the shoreline, some grid cells had a smaller surface area than the 10 x 10 nm grid. Therefore, we accounted for this by adding the variable grid size which was calculated as the km^2 area of each grid cell. We also tested whether the distance from the centre of each grid cell to the shore had a significant influence on site choice.

We estimated the model by pooling data across all 4 regions.

3.3 Policy scenarios

The model results of the RUM give information about how the site specific 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 probabilities for an individual to choose a certain site as well as the change in value derived from the visit 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 1). Scenarios included the removal of existing MMS as well as the addition of new MMS at certain sites (Figure 1). The loss in value associated with the removal of a particular MMS represents the value of that MMS. Added prospective MMS were assumed to be in the centre of the grid cells and the on-the-water travel cost was estimated from the boat ramp each respondent left to the centre of that grid cell. Note that we do not model selection of boat ramp, and hence cannot account for any change in choice of boat ramp prior to launch that may occur as a result of changing the MMS.

As Thevenard O&G infrastructure are closed to any recreational activity, we could not measure the values associated with this structure type. To understand the value associated with the potential diving and recreational fishing on Thevenard O&G infrastructure, we therefore changed the structure types into either "shipwrecks" or "artificial reefs" to imitate conditions that are more favourable to divers or recreational fishers, respectively (i.e. if a new MMS is designated as a "shipwreck" that is only intended to indicate that it has access settings equivalent to a shipwreck).


(A)
Bunbury
FV Lena
HMAS Swan
Dunsborough
Busselton
MMS
Artificial Reef
Busselton Jetty
Shipwreck
Boat ramp
Ngari Capes
Sanctuary Zone
Grid (10x10 nm)
Scenario: G25, G28
(B)
Onslow
Exmouth
Coral Bay
MMS
Artificial Reef
O&G platform
Navy Pier
Pipeline
Boat ramp
Muiron Islands Zoning
Conservation Area
North West AMP Network
National Park Zone
Recreational Use Zone
Grid (10x10 nm)
Scenario: C36, E37

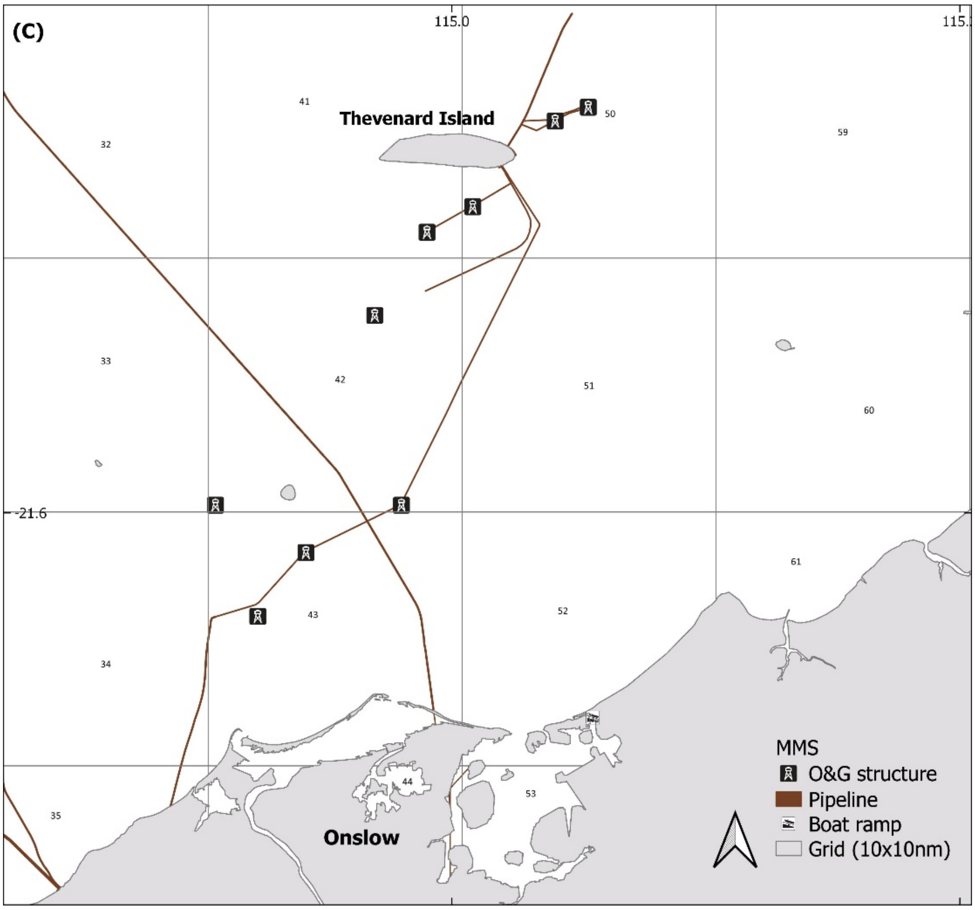


Figure 1: Study regions with grid, MMS and locations where MMS were hypothetically added for (A) Geographe Bay, (B) Coral Bay, Exmouth, and Onslow region, and (C) close-up of oil and gas structures in the Onslow region.

Table 1: 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 structure: 9 “artificial reefs”
W9	Access O&G structure: 9 “wrecks”
AR4W5	Access O&G structure: 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 structure: 2 “artificial reefs” (Roller B, Roller C)
W2	Access O&G structure: 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

4 Results and Discussion

4.1 Descriptive Analysis

4.1.1 Respondents’ characteristics

The random utility survey yielded 174 valid responses, out of which 123 were from recreational fishers and 51 from divers. Respondents’ characteristics are show in Table 2. Recreational fishers were on average eight years older than divers and were mainly male. Divers were on average more avid in their activity than recreational fishers, but both groups also engaged in the other activity. The majority of respondents live in the Perth metropolitan area.

Table 2: Respondents' characteristics from divers (n=51) and recreational fishers (n=123).

Respondent characteristics	Divers	Recreational Fishers	Total
Average age (years)	37	45	43
Gender (% male)	63.92	88.10	82.89
Avidity: Recreational fishing (%)			
Around once a year	8.89	4.09	5.03
Around once every three months	22.22	15.53	16.85
At least once a month	27.78	47.41	43.54
At least once a week	17.78	29.70	27.35
Never	23.33	0.00	11.67
Avidity: Diving (%)			
Around once a year	5.10	24.23	20.09
Around once every three months	18.37	24.23	22.96
At least once a month	38.78	18.59	22.96
At least once a week	36.73	2.82	10.15
Never	0.00	30.14	15.07
Postcode (%)			
Western Australia (total)	89.58	90.28	90.13
Perth metropolitan area	72.92	61.11	63.60
Margaret River region	7.29	16.11	14.25
Northwest	1.04	6.67	5.48
Other regions in WA	8.33	6.39	6.80
Other states	7.29	7.78	7.68

4.1.2 Level of Use of MMS

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 being 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 2). 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 3). 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 found very small numbers of visitors to the Onslow Region (Figure 4). Recreational fishers indicated 21 locations they visited, four being on MMS. Divers added six locations, three being on MMS. Coral Bay has got no MMS, so all trips recorded were taking place on natural sites (Figure 5).

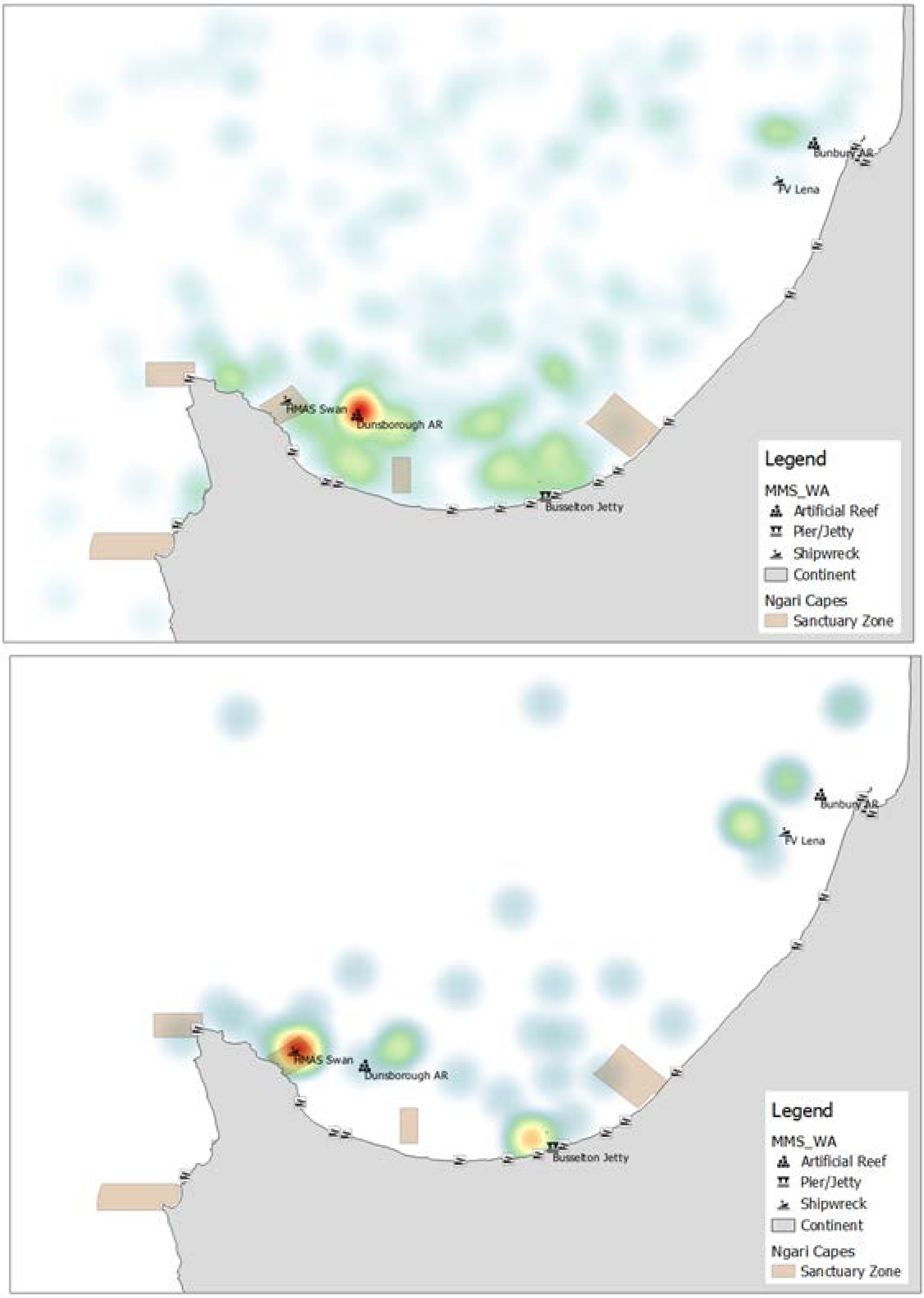


Figure 2: Frequency of trips for boat based (A) recreational fishing and (B) diving in Geographe Bay.

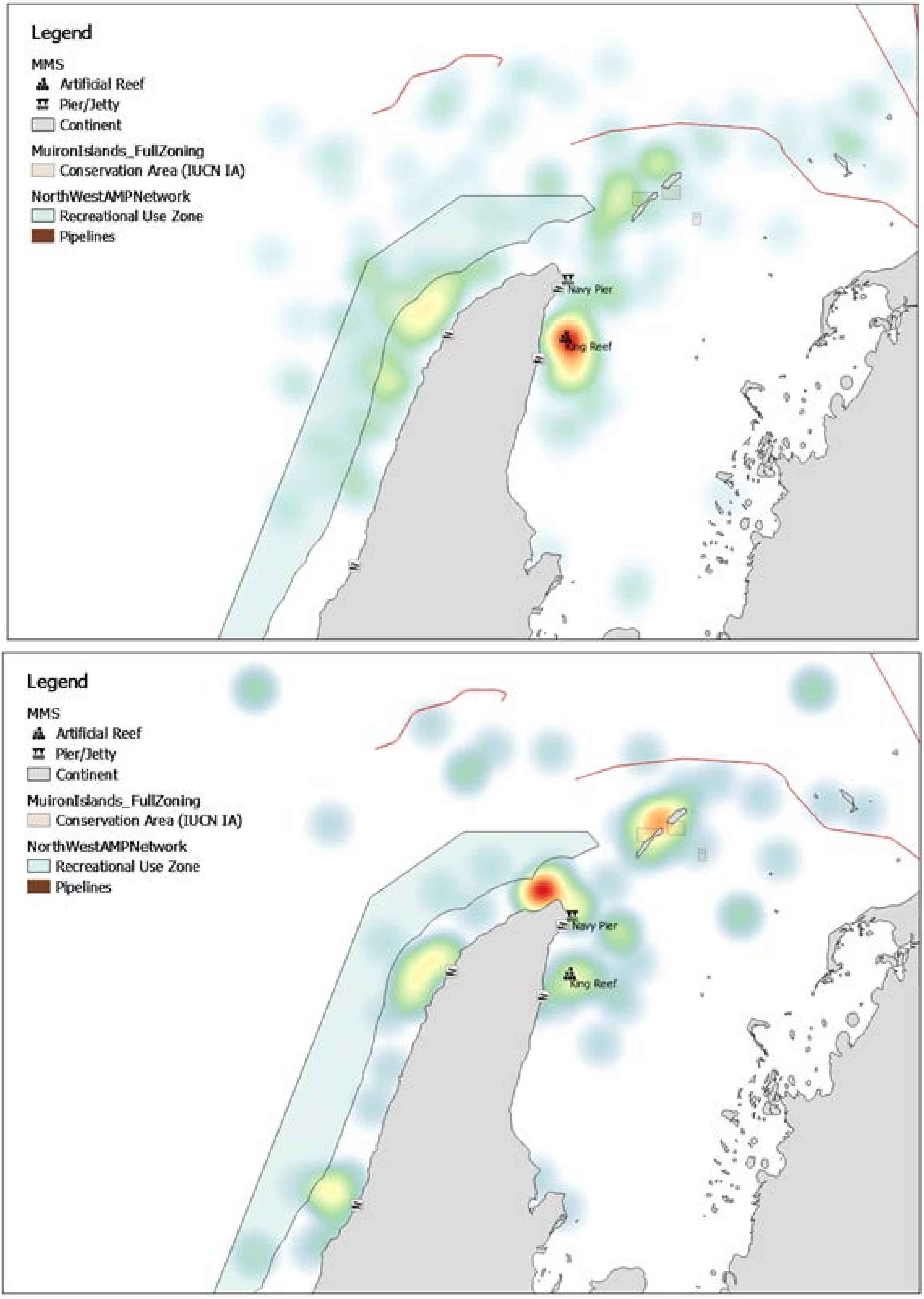
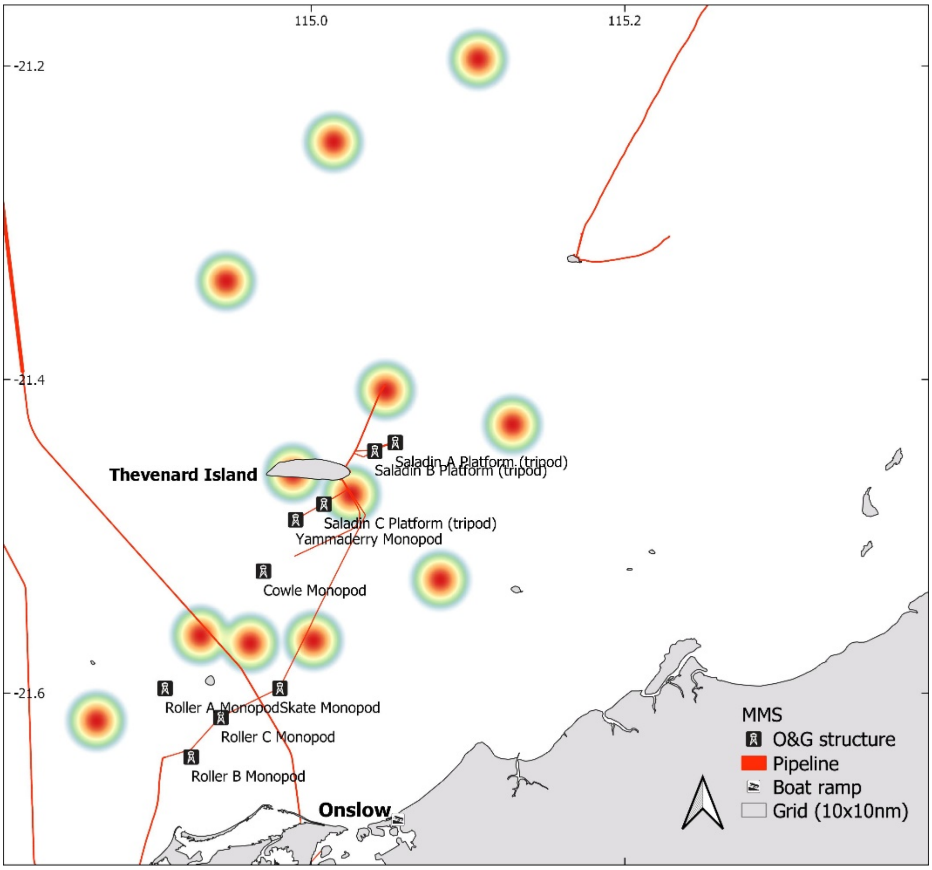


Figure 3: Frequency of trips for boat based (A) recreational fishing and (B) diving in the Exmouth region.



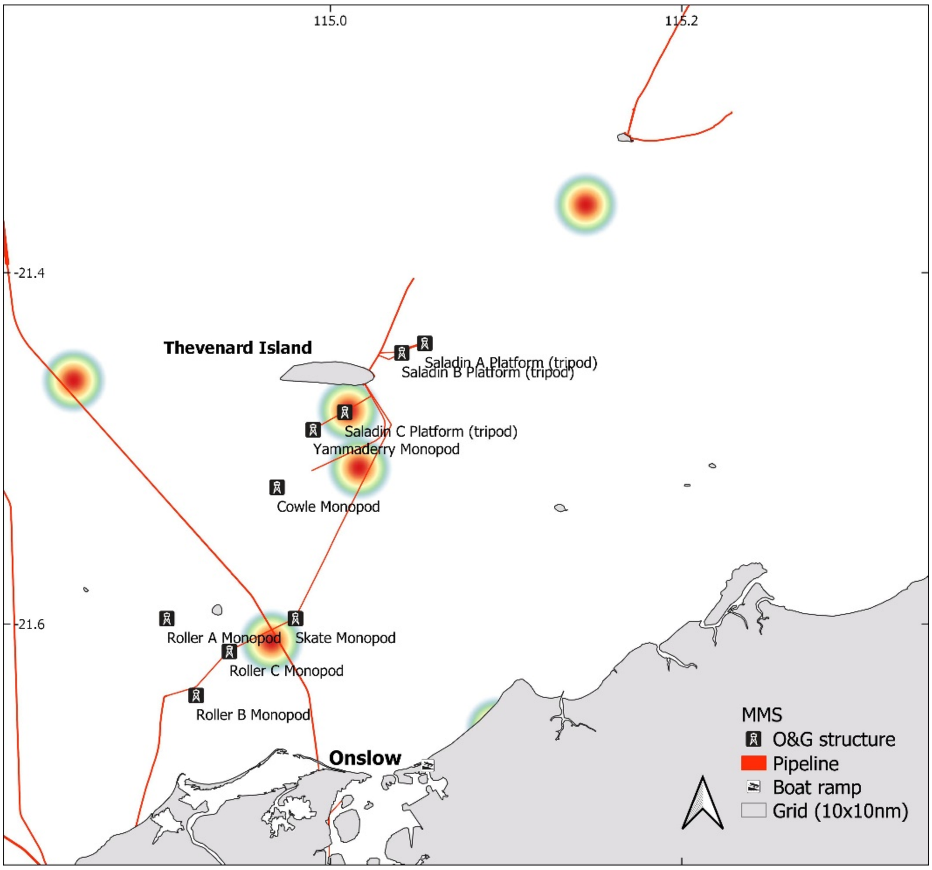


Figure 4: Frequency of trips for boat based (A) recreational fishing and (B) diving in the Onslow region.

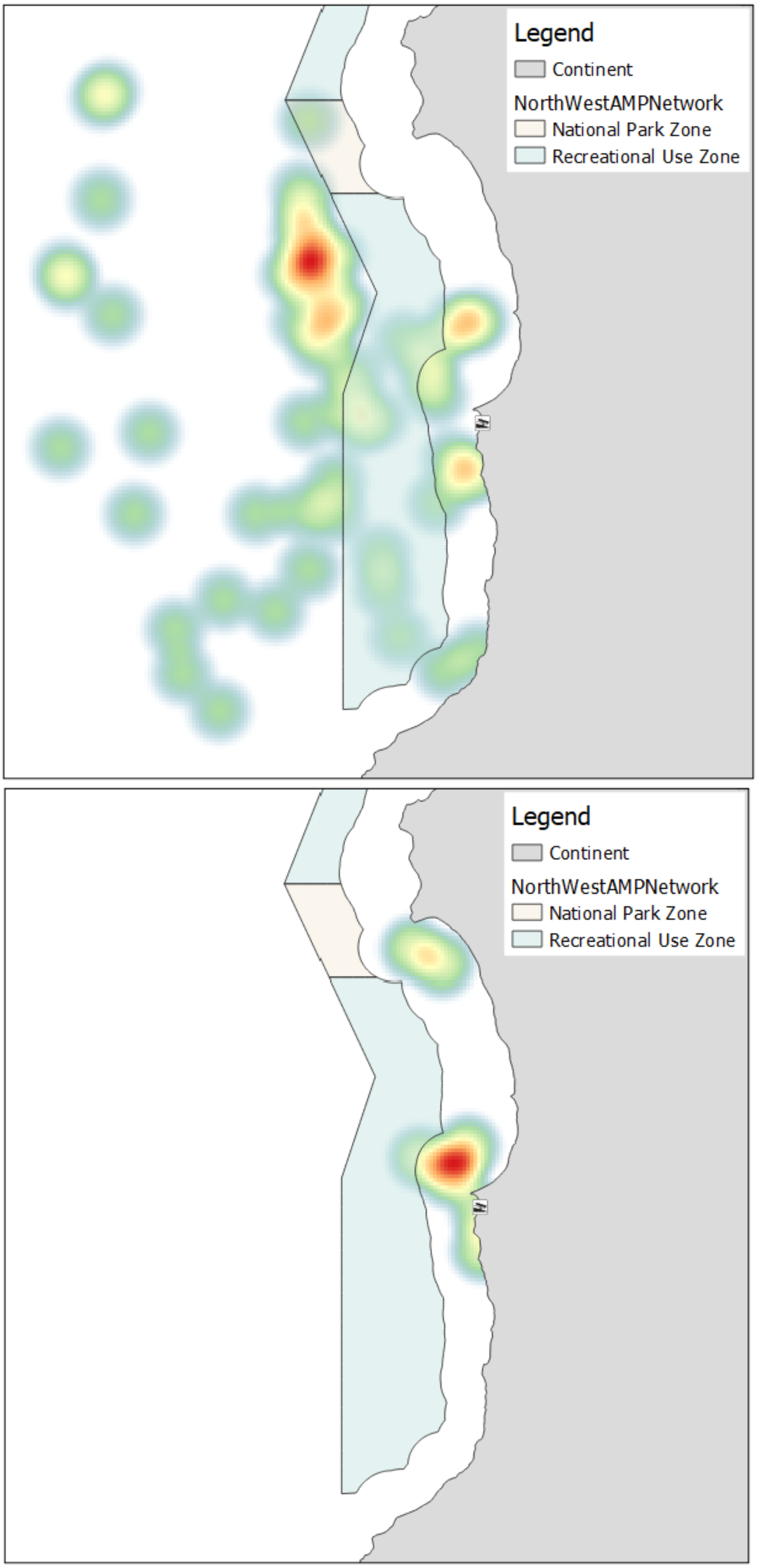


Figure 5: Frequency of trips for boat based (A) recreational fishing and (B) diving in Coral Bay.

4.2 Random Utility Model

We estimated a random utility model for both recreational fishers and divers (Table 3). As expected from economic theory, the travel cost coefficient has a significant and negative effect in both models. Artificial reefs influence site choice for recreational fishers strongly and positively, whereas there is 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 is only significant for divers. This is not surprising because both the Lena and the Swan shipwrecks are no-take zones (although note that a site was defined as to the zone as a whole, and hence it is possible that fishers visit a zone, without directly fishing on the wreck). However, recreational fishers might still benefit from spill-over effects from these zones. Respondents might also combine different activities and go fishing in the surroundings of the wrecks as well as dive on the wrecks during one trip. However, there is also indications of recreational fishing activities on the shipwrecks (local dive operator, personal comment).

The area of the grid positively affect site choice for both user groups. Moreover, fishers and divers have a preference for sites more distant from shore (conditional upon travel cost being a negative impact). This result might be explained by users trying to avoid overcrowding in areas closer to shore. This result might also be an indicator of overfishing in areas closer to shore.

Results of this model also reveal the willingness to pay (WTP) for MMS types for those who actually visit them and hence does not account for the substitution effect. Given that shipwrecks are closed to fishers it is not surprising that recreational fishers' WTP for access to zones containing artificial reefs is about twice that for shipwrecks. Also, the WTP of divers for jetties is about twice that for shipwrecks. This can probably be explained by the lower travel costs to the jetty than to the shipwrecks.

Table 3: 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

4.3 Change in Welfare under policy scenario

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 4). The simulation of site choice under the removal scenarios include the redistribution of users across the region, also called the substitution effect. Therefore, the values associated with these structures are lower than the WTP of respondents when not taking substitution into consideration. This estimate of the value is generated from the inclusive value of a region, with and without the change in MMS provision. Note that each region is considered separately i.e. there are no spill over effects across regions.

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

As expected, the sum of welfare change 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 is 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 is 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 4). 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 structures (Table 4). Again, we used the coefficients from “artificial reefs” and “wrecks” as a proxy because we have no estimates for O&G structures. Results indicate a decreasing marginal utility with additional MMS. 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 is also influenced by the fact that the scenario AR2 and W2 gave access to the two structures closest to shore which reduces travel costs. The scenario that combined O&G structures that are significant to fishers (artificial reefs) with those that are significant to divers (wrecks) (AR4W5) has the most equitable benefits.

Table 4: Hypothetical scenarios for MMS in Western Australia and the associated change in welfare (CS) for recreational fishers and divers.

Scenario	Description	Change in rec. fishers' CS (AUD/trip)	Change in divers' CS (AUD/trip)	Aggregate change in rec fishers' CS (AUD/year)	Aggregate change in rec divers' CS (AUD/year)
Geographe Bay					
BJ	Remove Busselton Jetty	-0.45	-0.56		
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					
C36	Add MMS (cell 36)*	0.02	-0.04		
Exmouth region					
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 structure: 9 "artificial reefs"	1.19	0.10	1,188
W9	Access O&G structure: 9 "wrecks"	0.21	1.06	210
AR4W5	Access O&G structure: 4 "artificial reefs" and 5 "wrecks"	0.50	0.60	499
AR2	Access O&G structure: 2 "artificial reefs"	0.53	0.05	529
W2	Access O&G structure: 2 "wrecks"	0.09	0.54	90

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

Our results are 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 is 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 suggests that the relative importance of MMS to recreational fishers is lower ($-6.16 AUD for removing all sites (from Raguragavan and Hailu, 2013) compared to our estimate of $-0.20 AUD for removing the EIAR). The access value of the Onslow region is relatively low ($2.95 AUD; Raguragavan and Hailu, 2013), hence, opening access to the O&G structures could increase the welfare of users significantly. Conversely, adding an MMS in Coral Bay would not add much to the welfare of users.

We did not have access to fishing data and could therefore not add the expected catch as a variable into our model. Previous studies have shown that the expected catch influenced site choice of recreational fisher significantly (Navarro et al. 2018, Raguragavan et al. 2013). Adding expected catch as a variable in future studies would be advisable to improve the results of this model.

5 References

Mean depth per grid cell: https://www.ga.gov.au/scientific-topics/national-location-information/topographic-maps-data/topographic-maps

http://www.ga.gov.au/scientific-topics/marine/survey-techniques/bathymetry

https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/67703

Appendix A: Random Utility Survey

BLOCK: RECREATIONAL FISHING

F.1 Have you done any private boat-based recreational fishing trips to any of the following areas in WA in the last 12 months? Please tick all boxes that apply. If none apply, please click the blue arrow button.

- ☐ Onslow (e.g. Thevenard Island)
- ☐ Coral Bay
- ☐ Exmouth
- ☐ Geographe Bay

Display This Question:

If If Have you done any private boat-based recreational fishing trips to any of the following areas in WA in the last 12 months? Please tick all boxes that apply. If none apply, please click th... q://QID4/SelectedChoicesCount Is Greater Than or Equal to 1

F.2 We are going to ask you now about your recent private boat-based recreational fishing trips. We are only interested in trips undertaken in the last 12 months. Each trip is defined as one day of activity. The information will help us to understand your reasons to choose a specific fishing site.

APPENDIX A

Block: Recreational fishing: Geographe bay

Display This Question:

If Have you done any private boat-based recreational fishing trips to any of the following areas in... = Geographe Bay

FG.0 Please tell us for each of your most recent fishing trips to Geographe bay, by boat, when it was, how far you traveled that day (in either km or nautical miles) and what you intended to catch.

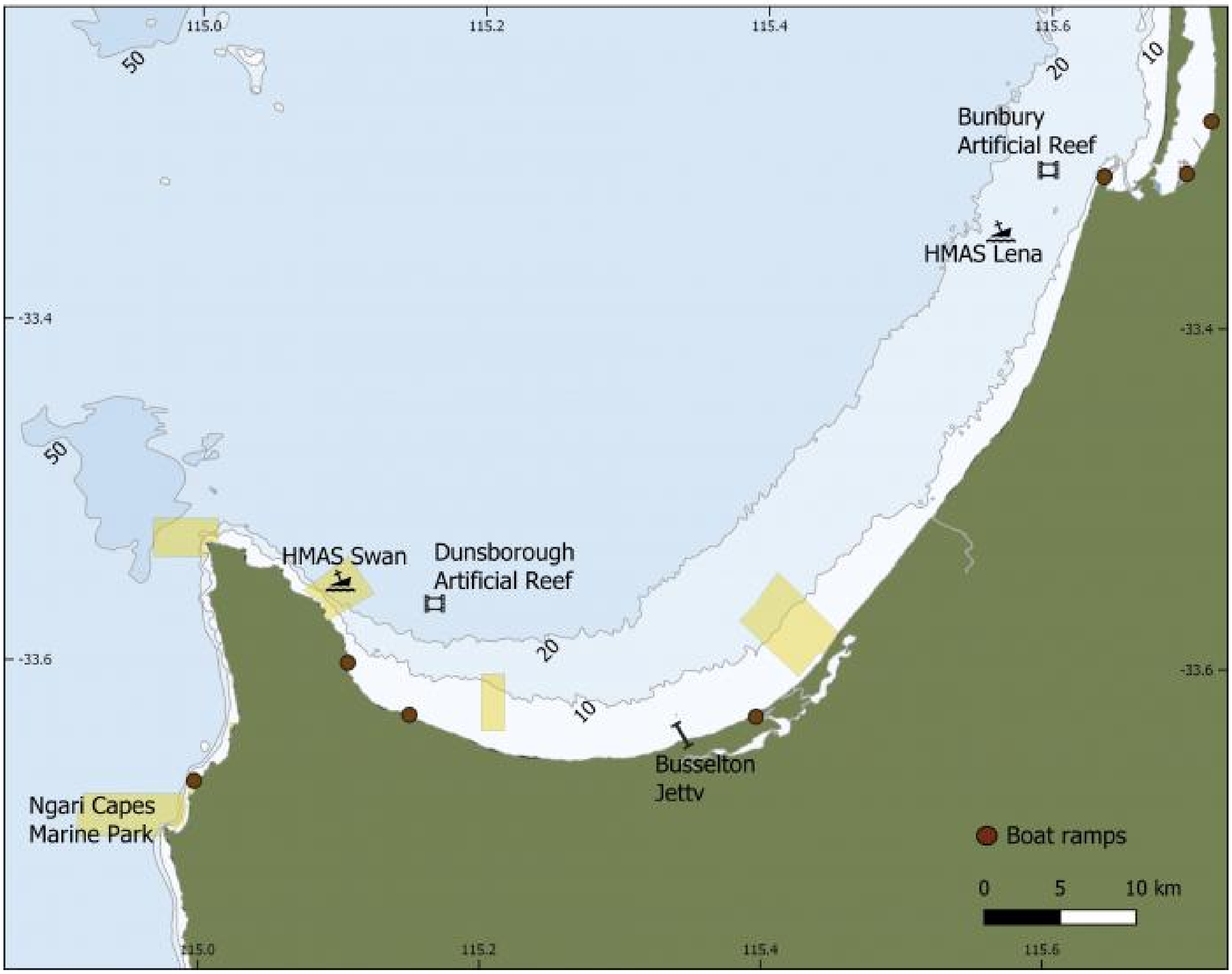
	Date	Distance traveled on water		Intended catch					
	(dd/mm/yyyy)	km	nm	bottom dwelling finfish (eg emperor, groper, snapper)	large pelagics (eg mackerel, tuna, marlin)	nearshore finfish (eg barramundi, whiting)	baitfish (eg sardine, anchovy)	crustaceans	molluscs and invertebrates
Trip 1				O	O	O	O	O	O
Trip 2				O	O	O	O	O	O
Trip 3				O	O	O	O	O	O
Trip 4				O	O	O	O	O	O
Trip 5				O	O	O	O	O	O

APPENDIX A

Display This Question:

If If Please tell us for each of your most recent fishing trips to Geographe bay, by boat, when it was,... Trip 1 - Date - (dd/mm/yyyy) Is Not Empty

FG.1 Please indicate where you spent the most time fishing on Trip 1 (on the ${FG.0%231/ChoiceTextEntryValue/1/1}, by clicking on a maximum of 3 locations on the map.



Repeated for a maximum of 5 trips.

APPENDIX A

Block: Recreational fishing: Coral Bay

Display This Question:

If Have you done any private boat-based recreational fishing trips to any of the following areas in... = Coral Bay

FC.0 Please tell us for each of your most recent fishing trips to Coral Bay when it was, how far you traveled that day (in either km or nautical miles) and what you intended to catch.

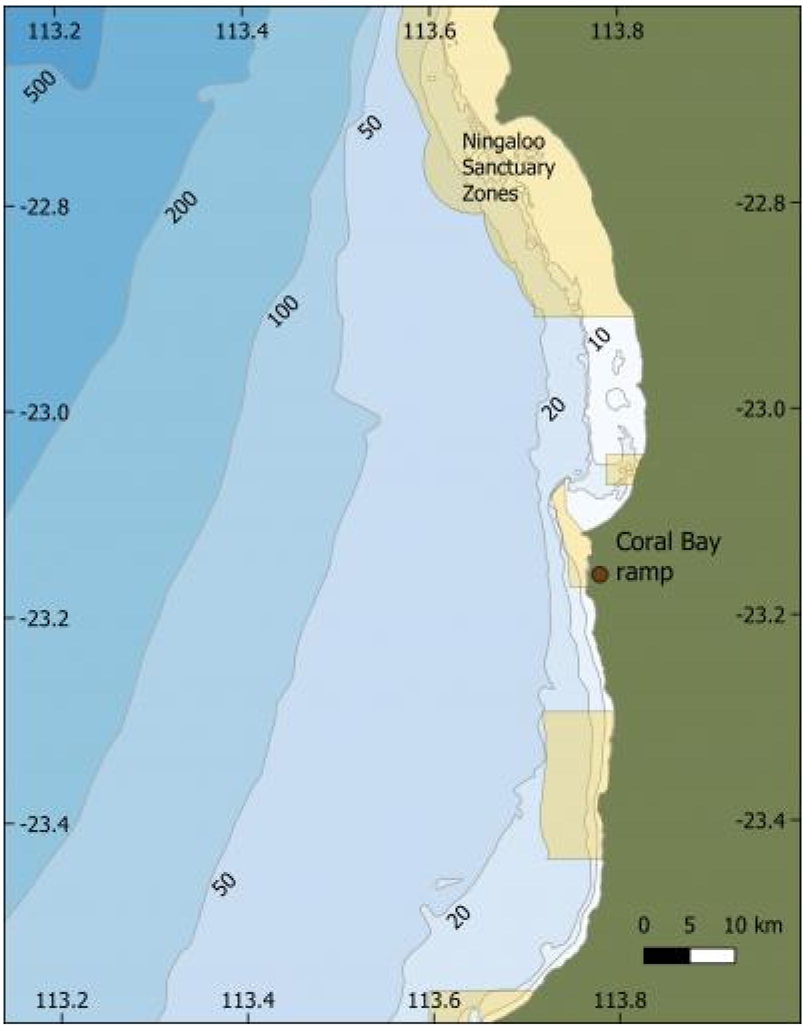
	Date	Distance traveled on water		Intended catch					
	(dd/mm/yyyy)	km	nm	bottom dwelling finfish (eg emperor, groper, snapper)	large pelagics (eg mackerel, tuna, marlin)	nearshore finfish (eg barramundi, whiting)	baitfish (eg sardine, anchovy)	crustaceans	molluscs and invertebrates
Trip 1				O	O	O	O	O	O
Trip 2				O	O	O	O	O	O
Trip 3				O	O	O	O	O	O
Trip 4				O	O	O	O	O	O
Trip 5				O	O	O	O	O	O

APPENDIX A

Display This Question:

If If Please tell us for each of your most recent fishing trips to Coral Bay when it was, how far you t... Trip 1 - Date - (dd/mm/yyyy) Is Not Empty

FC.1 Please indicate where you spent the most time fishing on Trip 1 (on the ${FC.0%231/ChoiceTextEntryValue/1/1}, by clicking on a maximum of 3 locations on the map.



Repeated for a maximum of 5 trips.

APPENDIX A

Block: Recreational fishing: Onslow region

Display This Question:

If Have you done any private boat-based recreational fishing trips to any of the following areas in... = Onslow (e.g. Thevenard Island)

FO.0 Please tell us for each of your most recent fishing trips to the Onslow region when it was, how you traveled on the water (in either km or nautical miles) and what you intended to catch.

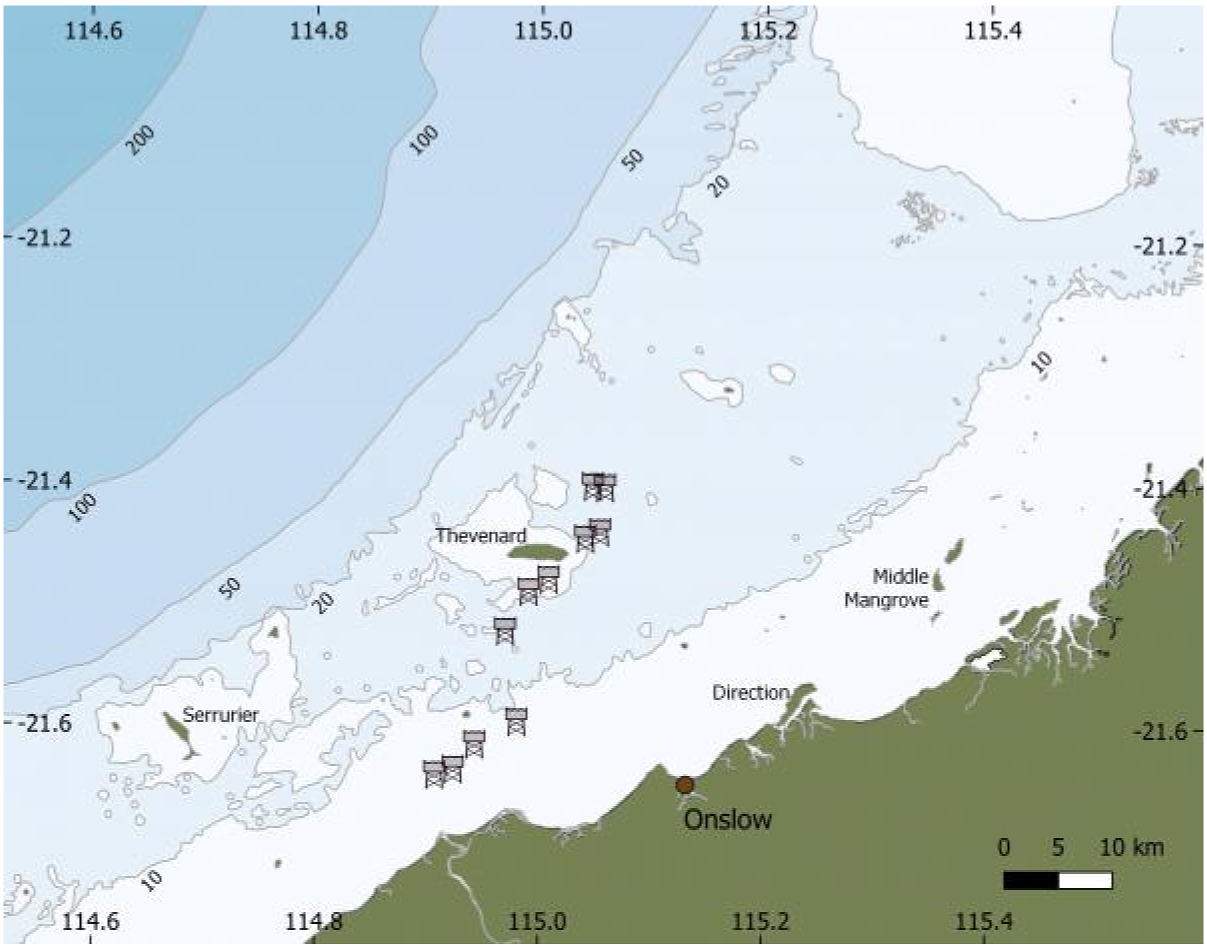
	Date	Distance traveled by water	Distance traveled by water	Intended catch					
	(dd/mm/yyyy)	(km)	(nautical miles)	bottom dwelling finfish (eg emperor, groper, snapper)	large pelagics (eg mackerel, tuna, marlin)	nearshore finfish (eg barramundi, whiting)	baitfish (eg sardine, anchovy)	crustaceans	molluscs and invertebrates
Trip 1				O	O	O	O	O	O
Trip 2				O	O	O	O	O	O
Trip 3				O	O	O	O	O	O
Trip 4				O	O	O	O	O	O
Trip 5				O	O	O	O	O	O

APPENDIX A

Display This Question:

If If Please tell us for each of your most recent fishing trips to the Onslow region when it was, how y... Trip 1 - Date - (dd/mm/yyyy) Is Not Empty

FO.1 Please indicate where you spent the most time fishing on Trip 1 (on the ${FO.0%231/ChoiceTextEntryValue/1/1}, by clicking on a maximum of 3 locations on the map.



Repeated for a maximum of 5 trips.

APPENDIX A

Block: Rec. fishing: Exmouth region

Display This Question:

If Have you done any private boat-based recreational fishing trips to any of the following areas in... = Exmouth

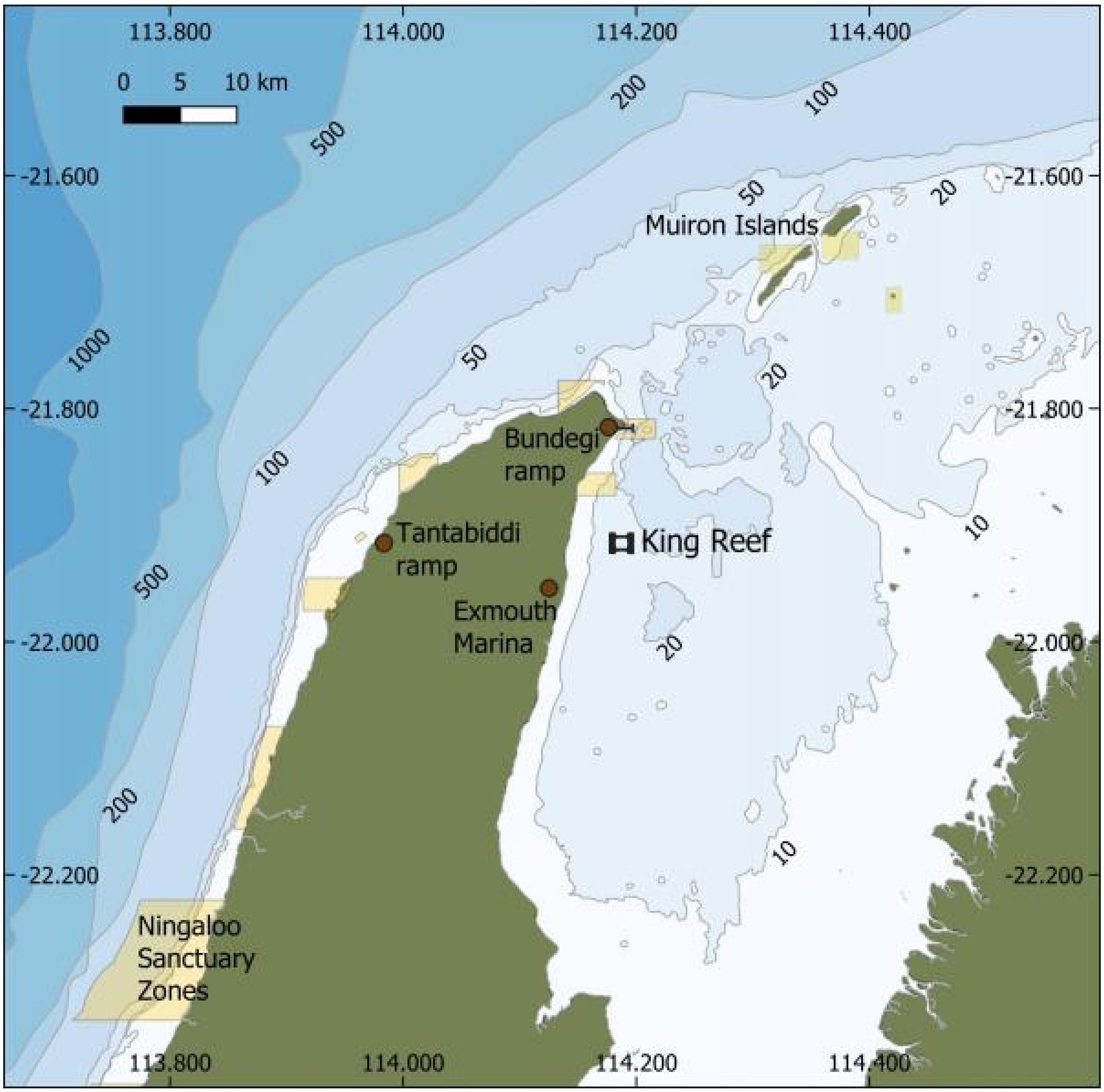
FE.0 Please tell us for each of your most recent private boat-based fishing trips to the Exmouth region when it was, from where you launched the boat and what you intended to catch.

	Date	Distance traveled on water		Intended catch					
	(dd/mm/yyyy)	(km)	(nautical miles)	bottom dwelling finfish (eg emperor, groper, snapper)	large pelagics (eg mackerel, tuna, marlin)	nearshore finfish (eg barramundi, whiting)	baitfish (eg sardine, anchovy)	crustaceans	molluscs and invertebrates
Trip 1				O	O	O	O	O	O
Trip 2				O	O	O	O	O	O
Trip 3				O	O	O	O	O	O
Trip 4				O	O	O	O	O	O
Trip 5				O	O	O	O	O	O

Display This Question:

If If Please tell us for each of your most recent private boat-based fishing trips to the Exmouth regio... Trip 1 - Date - (dd/mm/yyyy) Is Not Empty

FE.1 Please indicate where you spent the most time fishing on Trip 1 (on the ${FE.0%231/ChoiceTextEntryValue/1/1}, by clicking on a maximum of 3 locations on the map.



Repeated for a maximum of 5 trips.

APPENDIX A

Block: Recreational diving

D.1 Have you done any private boat-based diving trips to any of the following areas in WA in the last 12 months? Please tick all boxes that apply

- ☐ Onslow (e.g. Thevenard Island)
- ☐ Coral Bay
- ☐ Exmouth
- ☐ Geographe Bay

Display This Question:

If If Have you done any private boat-based diving trips to any of the following areas in WA in the last... q://QID70/SelectedChoicesCount Is Greater Than or Equal to 1

D.2 We are going to ask you now about your recent private boat-based diving trips. Each trip is defined as one day of activity. The information will help us to understand your reasons to choose a specific diving site.

Block: Recreational diving: Geographe bay

Display This Question:

If Have you done any private boat-based diving trips to any of the following areas in WA in the last... = Geographe Bay

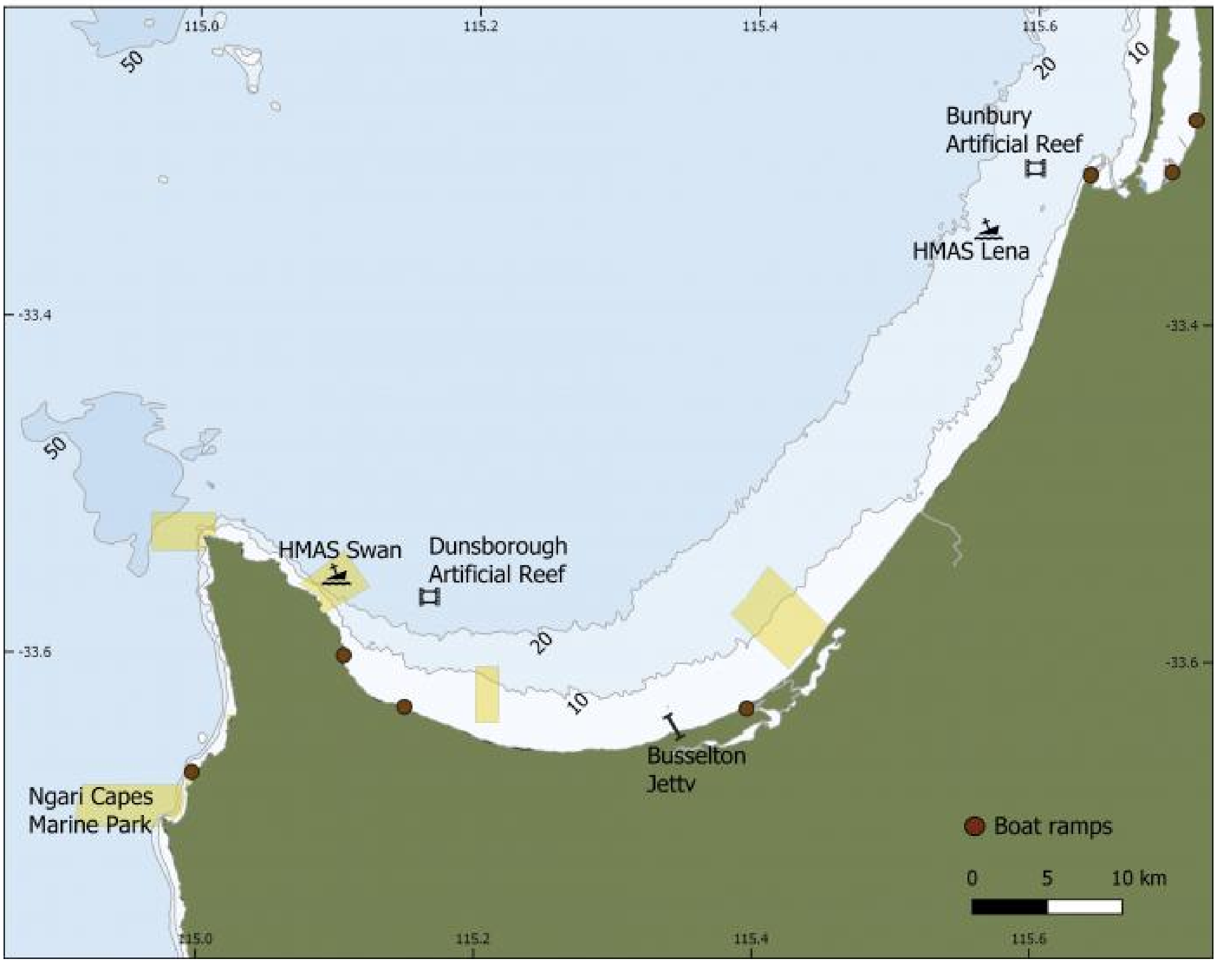
DG.0 Please tell us for each of your most recent **private boat-based diving trips** to the Geographe Bay region when it was, the distance you traveled on water in that trip, either in km or nautical miles, and what you intended to see underwater.

	Date	Distance traveled on water		Intended observation
	(dd/mm/yyyy)	(km)	(nautical miles)	(maximum 3 species or attractions)
Trip 1				
Trip 2				
Trip 3				
Trip 4				
Trip 5				

Display This Question:

If If Please tell us for each of your most recent private boat-based diving trips to the Geographe Bay region when it was, the distance you traveled on water in that trip, either in km or nautical ... Trip 1 - Date - (dd/mm/yyyy) Is Not Empty

DG.1 Please indicate where you spent the most time diving on Trip 1 (on the ${DG.0%231/ChoiceTextEntryValue/1/1}, by clicking on a maximum of 3 locations on the map.



Repeated for a maximum of 5 trips.

Block: Recreational diving Exmouth region

Display This Question:

If Have you done any private boat-based diving trips to any of the following areas in WA in the last... = Exmouth

DE.0 Please tell us for each of your most recent private boat-based diving trips to the Exmouth region when it was, from where you launched the boat and what you intended to see underwater.

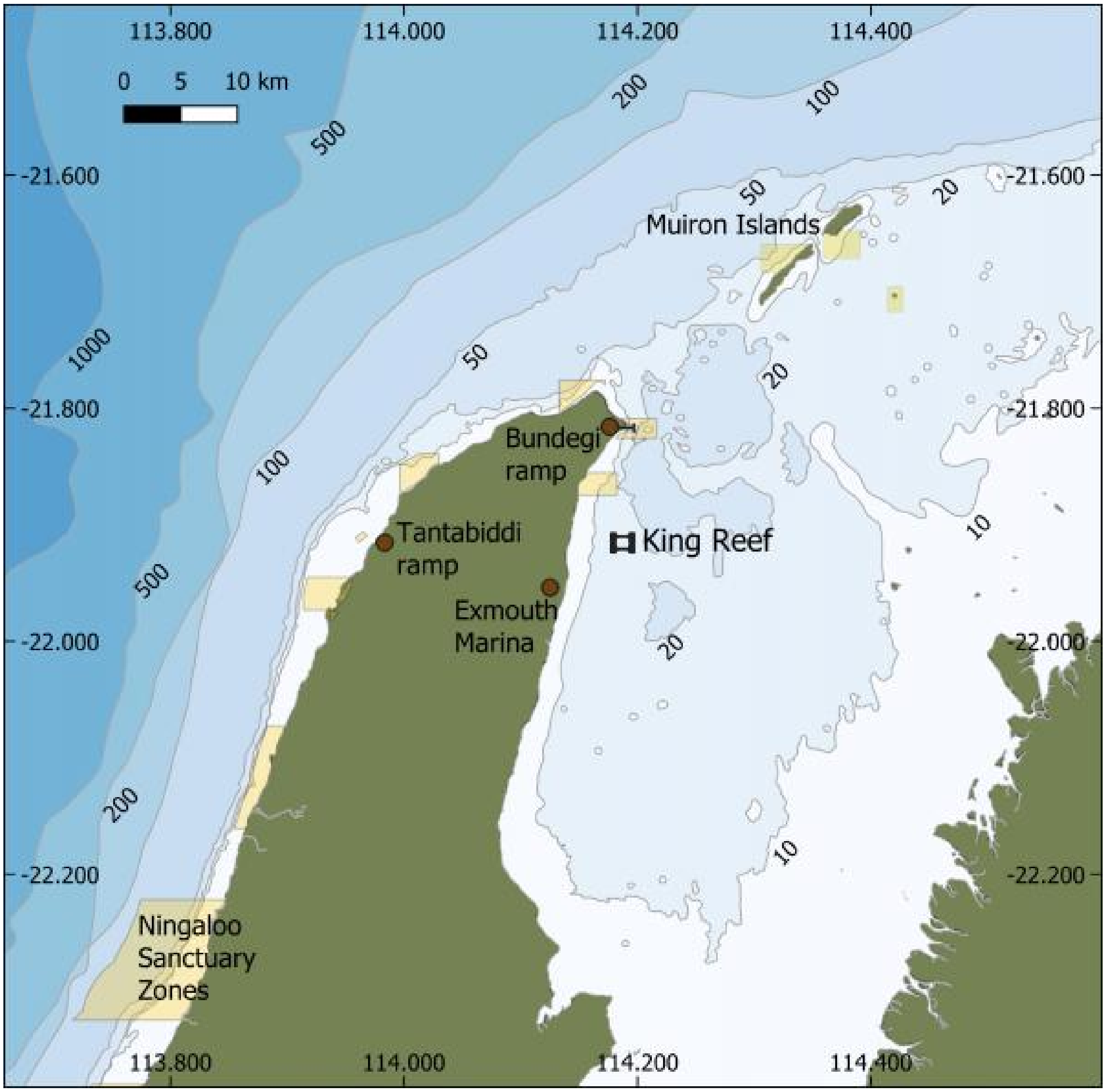
	Date	Distance traveled on water		Intended observation
	(dd/mm/yyyy)	(km)	(nautical miles)	(maximum 3 species or attractions)
Trip 1				
Trip 2				
Trip 3				
Trip 4				
Trip 5				

Display This Question:

If If Please tell us for each of your most recent private boat-based diving trips to the Exmouth region... Trip 1 - Date - (dd/mm/yyyy) Is Not Empty

APPENDIX A

DE.1 Please indicate where you spent the most time diving on Trip 1 (on the ${DE.0%231/ChoiceTextEntryValue/1/1}, by clicking on a maximum of 3 locations on the map.



Repeated for a maximum of 5 trips.

Block: Recreational diving Coral Bay

Display This Question:

If Have you done any private boat-based diving trips to any of the following areas in WA in the last... = Coral Bay

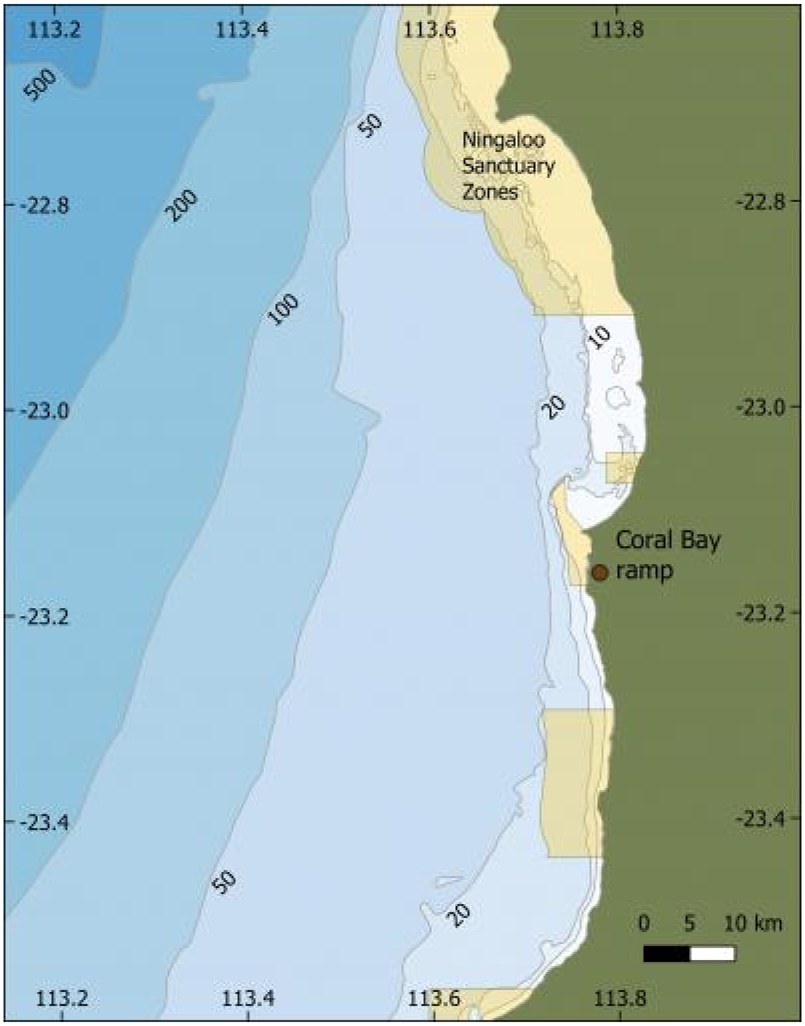
DC.0 Please tell us for each of your most recent **private boat-based** diving trips to the Coral Bay when it was, from where you launched the boat and what you intended to see underwater.

	Date	Distance traveled on water		Intended observation
	(dd/mm/yyyy)	(km)	(nautical miles)	(maximum 3 species or attractions)
Trip 1				
Trip 2				
Trip 3				
Trip 4				
Trip 5				

Display This Question:

If If Please tell us for each of your most recent private boat-based diving trips to theCoral Bay when it was, from where you launched the boat and what you intended to see underwater. Trip 1 - Date - (dd/mm/yyyy) Is Not Empty

DC.1 Please indicate where you spent the most time diving on Trip 1 (on the ${DC.0%231/ChoiceTextEntryValue/1/1}, by clicking on a maximum of 3 locations on the map.



Repeated for a maximum of 5 trips.

Block: Recreational diving Onslow region

Display This Question:

If Have you done any private boat-based diving trips to any of the following areas in WA in the last... = Onslow (e.g. Thevenard Island)

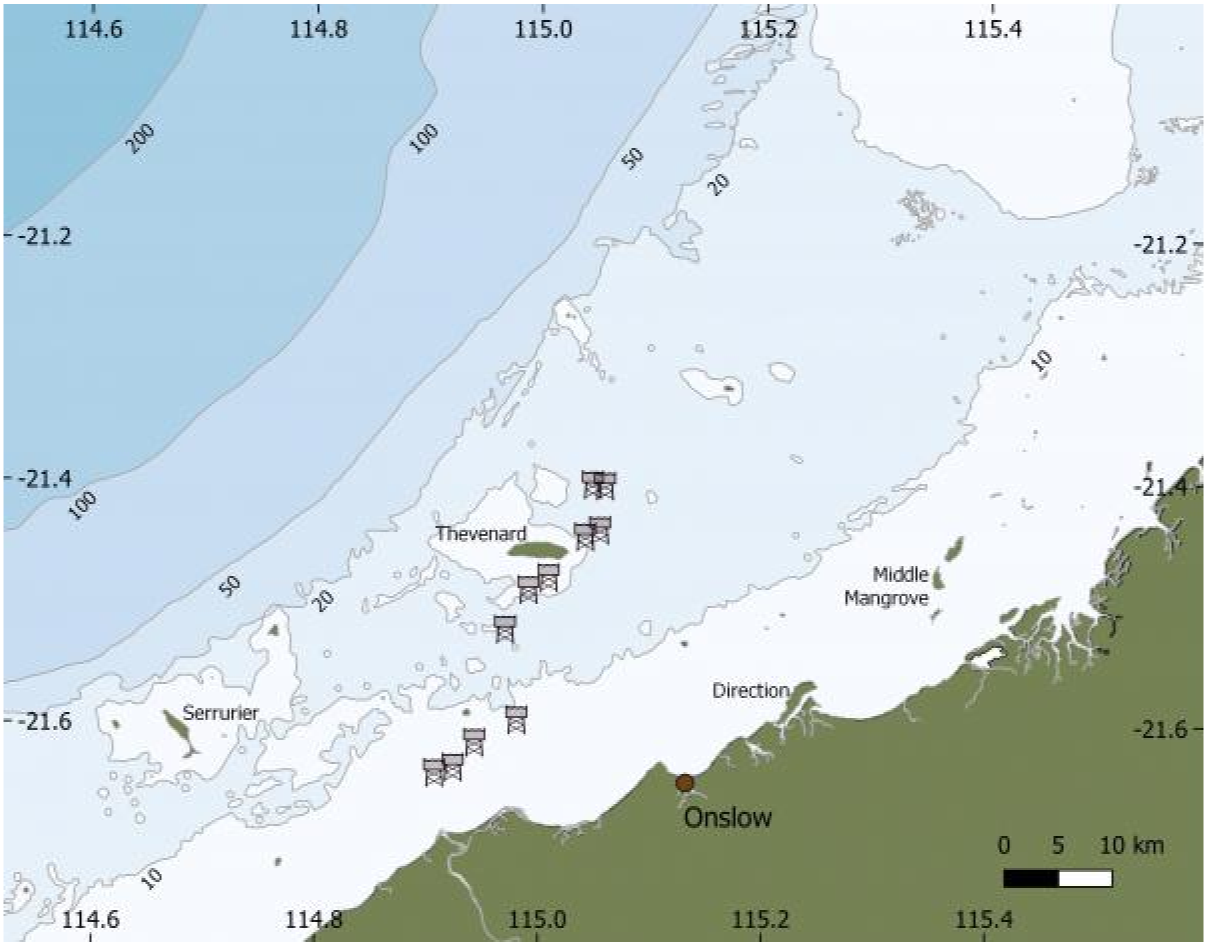
DO.0 Please tell us for each of your most recent **private boat-based** diving trips to the Onslow region when it was, from where you launched the boat and what you intended to see underwater.

	Date	Distance traveled on water		Intended observation
	(dd/mm/yyyy)	(km)	(nautical miles)	(maximum 3 species or attractions)
Trip 1				
Trip 2				
Trip 3				
Trip 4				
Trip 5				

Display This Question:

If If Please tell us for each of your most recent private boat-based diving trips to the Onslow region when it was, from where you launched the boat and what you intended to see underwater. Trip 1 - Date - (dd/mm/yyyy) Is Not Empty

DO.1 Please indicate where you spent the most time diving on Trip 1 (on the ${DO.0%231/ChoiceTextEntryValue/1/1}, by clicking on a maximum of 3 locations on the map.



Repeated for a maximum of 5 trips.

Block: Comments

Q44 Do you have any other comments you would like to make?

Appendix 7 Community perceptions of rigs-to-reefs in Western Australia

Verónica Mariana Recondo, Michael Burton & Johanna Zimmerhackel

This appendix is part of the final report for:

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

Euan S. Harvey, Fran Ackermann, Michael Burton, Julian Clifton, Carmen Elrick-Barr, Johanna Zimmerhackel, Georgina Hill, Stephen J Newman, Jenny Shaw, Mark Pagano, Paul McLeod, Dianne McLean, Julian Partridge

24th August 2021

FRDC Project No **2018-053**

This report is an edited version of a Masters thesis, submitted by Veronica Recondo in partial fulfilment of the requirements for a Masters in Environmental Science, UWA School of Agriculture and Environment, UWA 2020.

Community perceptions of rigs-to-reefs in Western Australia

Verónica Mariana Recondo, Michael Burton, Johanna Zimmerhackel

Abstract

Current regulations in Australia favour complete removal of decommissioned offshore oil and gas infrastructure. However, regulators could consider an *in-situ* decommissioning policy if this provides ecological and socio-economic values to different stakeholders, including the wider community. Therefore, the aim of this study was to assess Western Australia community members' preferences towards rigs-to-reefs as an alternative option to complete removal and estimate the extent to which these preferences could be influenced by their attitudes towards the oil and gas sector. Hence, a discrete choice experiment and a social licence to operate survey were conducted on a random sample of Perth residents. 9.4% of respondents opposed to 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. Preferences for reefs increased if it could provide either habitat for threatened species, increased fish biomass, production of fishes, 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 oil and gas sector was low.

Key words: decommissioning, discrete choice experiment, oil and gas, rigs to reefs, social licence to operate

1. Introduction

Australia has a significant number of offshore oil and gas platforms, with some of them currently reaching the end of their life cycle (Shaw et al. 2018). Regulations such as the Offshore Petroleum and Greenhouse Gas Storage (Environment) Act 2009, and the Environment Protection (Sea Dumping) Act 1981, favour their complete removal from the ocean by safely plugging wells and removing all the associated equipment (DIIS 2018; Shaw et al 2018). However, the Australian regulator in charge of decommissioning - the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) - is currently evaluating an *in-situ* decommissioning policy, which may include partial removal, nearby relocation or leaving the structures in place (Chandler et al. 2017; DIIS 2018; Bull and Love 2019). This alternative approach may be implemented if a company can prove that it generates equal or better environmental, safety and well integrity outcomes, or if complete removal would present a greater risk or cost for the environment (Chandler et al. 2017; DIIS 2018). Such a scenario would be possible in cases where marine life has developed around rigs, therefore allowing these structures to be used as artificial reefs through the creation of rigs-to-reefs programs (Chandler et al. 2017). These programs have already been established in some countries such as the USA, Malaysia and Brunei (Advisian 2017; Bull and Love 2019). In the USA, the National Rigs-to-Reefs Plan was created in 1985 and it is regulated by the Bureau of Safety and Environmental Enforcement (BSEE) (Advisian 2017). In other regions, such as the North Sea, policies still favour complete removal of structures due to the regulations of the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR) and the OSPAR Decision 98/3, which prohibits the disposal of decommissioned offshore oil and gas platforms in the sea (Bull and Love 2019).

The different decommissioning approaches that allow the structures to be disposed *in-situ* (Figure 1) consider the potential ecological values of the ecosystems that have developed around them (Sommer et al. 2018). These potential ecological values may include: habitat provision for biological communities (Sommer et al. 2018); potential fish biomass production – although it is not entirely clear if fishes are being reproduced in the vicinity of the platforms or just being attracted to them (Bohnsack 1989; Claisse et al. 2014); enhancement of biodiversity (van der Stap et al. 2016; Coolen et al. 2018); biota protection from trawl fishing within platform exclusion zones through the risk of snagging (Schroeder and Love 2004; Inger et al. 2009); and connectivity of native populations over large distances through the "stepping-stone" effect, including protected or endangered species (Bishop et al. 2017; Henry et al. 2018). However, these structures may also facilitate the expansion of non-native and invasive species (Bulleri and Airoldi 2005; Page et al. 2006; Glasby et al. 2007; Sheehy and Vik 2010). Also, navigational and snagging hazards to shipping and fishing may occur if the rigs are not adequately identified (Advisian et al. 2017). In addition, *in situ* decommissioning of structures may involve a risk of corrosion, which may lead to the release of contaminants to the environment. Yet, removing the structures from the sea may also include a risk of contamination due to seabed disturbance and possible resuspension of contaminants (Advisian et al. 2017). As noted by Shaw et al. (2018), there is still limited information regarding these issues in Australia, as there are few decommissioned assets.

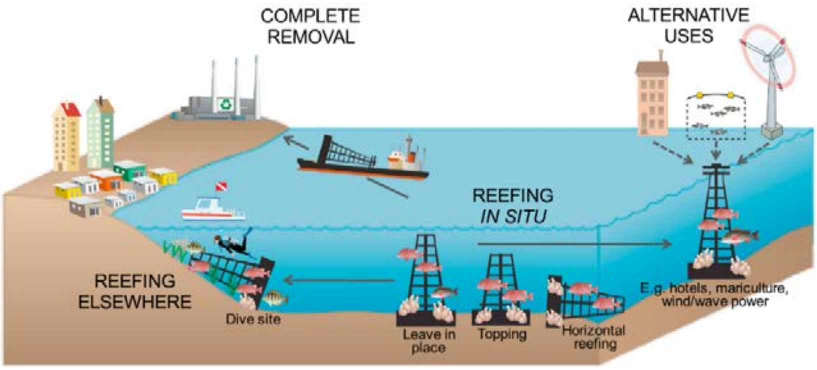


Figure 1. Offshore oil and gas decommissioning options (Source: Sommer et al. 2018)

In the case of Australia, some ecological values have been reported by several studies conducted in the North West Shelf (NWS) of Western Australia, suggesting that subsea oil and gas infrastructure in this region may be important habitats for fishes, as well as support high biomass and diversity of species, including commercially targeted ones (Pradella et al. 2014; McLean et al. 2017; Bond et al. 2018a, Bond et al. 2018b; McLean et al. 2018; McLean et al. 2019). Moreover, McLean et al. (2018) and McLean et al. (2019) have found IUCN endangered and vulnerable species associated with platforms' jackets. Hence, offshore oil and gas infrastructure could be also presenting potential socio-economic values for local fisheries and tourism industry through the provision of fishing and diving opportunities (Advisian 2017). Therefore, it becomes essential to evaluate information using a multi-disciplinary and holistic approach that includes the environmental, technical and socio-economic aspects of decommissioning, as well as the interests of different stakeholders (Chandler et al. 2017; DIIS 2018; Shaw et al. 2018). As noted by Chandler et al. (2017, p. 346) "*one critical input to such a holistic approach will be determining the value for stakeholders* - including the broader community - *of various potential re-uses of decommissioned infrastructure, including the* *development of artificial reefs"*. Moreover, for some stakeholders this is a contested space, with some of them opposed to the disposal of oil and gas infrastructure in the sea (Abott 1996). In this regard, Shaw et al. (2018, p. 4) highlights that *"it is not clear if stakeholders and the general community will support a shift in policy to regularly support options other than complete or near-complete removal"*. Therefore, community perception of different decommissioning approaches becomes an important issue to be considered in decision making, being of primary relevance for State and Commonwealth Government Agencies (Shaw et al. 2018).

Moreover, it may be the case that people's attitudes towards the oil and gas sector influence their perception of different environmental outcomes related to this industry, and hence whether they would be willing to accept a change in policy from complete removal (Salcido 2005). In this regard, a Social License to Operate (SLO) has been previously used by other authors (Richert et al. 2015; Burton et al. 2017) to measure these attitudes and explain people's choices.

Regarding the value of rigs-to-reef for different stakeholders, several studies have assessed the economic impact of this alternative using market and non-market valuation in countries where this policy has been implemented. In a recent report, McLeod et al. (2019) found five studies that evaluate the potential economic value of artificial reefs derived from oil and gas infrastructure, for different stakeholders. Among these studies, Islam et al. (2014) examined the economic benefits of oil and gas reefs on artisanal fishers in Malaysia, while McGurrin and Fedler (1989) studied the willingness to pay of recreational fishermen for the development of artificial reefs projects on a petroleum platform in Florida, USA. Likewise, Roberts et al. (1985) used a contingent valuation to estimate the economic value of recreational diving on oil rigs in Louisiana, USA, while Ditton et al. (2002) and Oh et al. (2008) estimated the economic impacts of recreational diving for scuba divers in both natural and rigs-to-reefs habitats in Texas, USA using divers' expenditure per dive trip in the former, and a contingent valuation study in the latter. In addition, Hiett and Milon (2002) estimated the overall economic impact of recreational fishing and diving associated with offshore oil and gas structures in the Gulf of Mexico, USA. However, none of these economic studies have analysed public acceptance, perceptions and/or valuation of rigs-to-reefs, nor has this been analysed in the Australian context despite its current relevance.

Therefore, the aims of this study are:

1) Assess Western Australia community members' preferences towards rigs-to-reefs as an alternative option to complete removal of offshore oil and gas infrastructure, and estimate the relative values hold by the community members for different attributes of rigs-to-reefs policy.

2) Assess Western Australia community members' attitudes towards the oil and gas sector by measuring the SLO by the community members granted to this sector, and estimate the extent to which these attitudes could influence their preferences among the two policy alternatives: complete removal vs. rigs-to-reefs.

Regarding the second aim, the hypothesis is that the degree of SLO granted by the Western Australian community members to the oil and gas sector will significantly influence their attitudes towards rigs-to-reefs, and hence their choices in any discrete choice experiment (DCE).

This research intends to contribute to the decision process regarding community preferences towards rigs-to-reefs, as well as improve our understanding of the elements of this approach that could increase or decrease their acceptance.

2. Methodology

2.1 Choice modelling theory

Non-market valuation is a methodology that allows one to assign economic value to environmental goods and services that are not traded in markets, and quantify people's preferences towards potential changes in environmental outcomes. Stated preference studies are a subset of the valuation techniques, which use surveys to evaluate hypothetical behaviour (as compared to revealed preference studies that rely on observed behaviour). Stated preference studies can potentially identify values related to both 'use' and 'existence' values (i.e. use-values which relate to values that depend on direct interaction with the resource of interest, such as fishing, and existence-values that may be held by people who do not have direct interaction with the resource, but who still hold values for the state of that environment). Further, it is possible that within a single study both values may be expressed, potentially by the same respondent i.e. a recreational fisher may consider both the positive consequences for their fishing activity, and the impacts on endangered species , when asked about their support for the development of an artificial reef. Within the statistical analysis it is possible to identify if these multiple values are being expressed.

One of the stated preference techniques commonly used to estimate these preferences are discrete choice experiments (DCEs) (Bateman et al. 2002). This technique allows one to assess people's preferences across alternative policy scenarios, which are described by a number of characteristics (called attributes) that can take a number of different levels. Therefore, by making a choice between the different alternatives, the respondents evaluate the utility they obtain from the attributes of the chosen option. This behaviour can be described by the random utility model (RUM) (McFadden 1974; Train 2009) such that the utility (U_{ij}) that individual *i* gains from selecting alternative *j* in a choice set is given by:

$$U_{ij} = \beta X_j + \varepsilon_{ij} \tag{1}$$

where X denotes a vector of observable attribute levels describing alternative *j*; β the utility weights that apply to them; and ε_{ij} a random component unobservable to the researcher (error). The error is introduced in the model given that respondents may evaluate the different alternatives according to information other than that shown in the choice set (Bateman et al. 2002). Therefore, the probability of individual *i* choosing alternative *j* over all other alternatives in a choice set, can be expressed as the probability that the utility associated with that alternative exceeds the utility associated with any other alternative *k*, which is given by:

$$P_{ij} = P\left[\left\{\beta X_j + \varepsilon_{ij}\right\} \geq \{\beta X_k + \varepsilon_{ik}\}\right] \quad \forall_j \neq k \tag{2}$$

Assuming that the errors, ε_{ij}, are independently and identically distributed with an extreme-value type I (Gumbel) distribution, then the respondent's probability of choosing alternative *j* as the most preferred, can be expressed as a multinomial logit model (McFadden 1974):

$$P_{ij} = \frac{\exp(\beta X_j)}{\sum_{k=1}^{J} \exp(\beta X_j)} \tag{3}$$

This model produces estimates of the coefficient vector β for each attribute, which is interpreted as the utility weights, and hence the relative values held for the different attributes. Since the attributes in this study also include a monetary attribute *m* (explained in the next section), for which the estimated parameter is β_m, mean willingness to pay (WTP) for any non-monetary attribute *n* was calculated as

$$WTP_n = -\frac{\beta_n}{\beta_m} \tag{4}$$

where β_n denotes the coefficient of the attribute *n*.

It is worth noting that, if the monetary attribute represents a cost for the respondent, that formula gives the WTP for a unit increase in a non-monetary attribute. But, if the monetary attribute represents a payment to the respondent (and hence β_m is expected to be +ve), then (4) without a negative sign gives the amount of money they are WTP (i.e. forgo) to get a unit increase in the attribute.

The DCE approach was considered an appropriate methodology for this research as it allows one to elicit community preferences and analyse the trade-offs that people are ready to make between the policy scenarios.

2.2 Choice experiment design and selection of attributes

A DCE was designed to identify public preferences regarding rigs-to-reefs and quantify what aspects of this policy could influence acceptance of the community members. The DCE included attributes that reflect potential ecological, social and economic outcomes, so preferences can be revealed. The framing and attributes are described as follows.

Respondents were first provided with some background information, in which it was indicated that the complete removal option is the current decommissioning policy and it would mean returning the seabed as close as possible to its natural condition. The removed structures would be brought onshore for recovering and recycling of the steel, and those parts that cannot be recycled would be disposed to landfill. Regarding the rigs-to-reefs option, it was specified that they could provide habitat for marine species and increase species diversity, as well as be used for recreational fishing and diving. It was also indicated that corrosion on structures left in the sea may occur, resulting in the release of contaminants to the marine environment. It was added that, complete removal would eliminate this possibility, although it could also increase the risk of seabed disturbance and re-suspension of contaminants during removal.

The choice sets were based on a hypothetical scenario in which an oil platform is coming to the end of its lifecycle in the NWS of Western Australia and needs to be decommissioned. Such a procedure would require AU$ 200 million expenditure by the oil and gas company if the structure has to be entirely removed from the sea, this being the base case scenario (*status quo*). This value was estimated using the projections made by DIIS (2018, p.5), who reported that "*approximately 136 fixed facilities (including pipelines) are likely to commence decommissioning activities in the coming decade, and over the next 50 years Australia's offshore petroleum industry's decommissioning liability is estimated to be US$21 billion*".

Thus, US$ 21 billion/136 = US$ 154.411.764 = AU$ 223.464.704 according to the exchange rate on 16/1/ 2020 (XE 2020). This number was then rounded to AU$ 200 million.

The alternative to the status quo was the option to convert the rig to a reef, under alternative ecological and policy frameworks. Each policy scenario was described by six attributes (five non-monetary and one monetary).

The first attribute was total fish biomass, which is a measure of the amount of fishes that could be found on these structures. Harvey et al. (2020) estimate the value to be 1 tonne for one platform jacket. In the choice experiment respondents were told that the amount of total fish biomass could be 0.5 tonnes, 1 tonne or 1.5 tonnes.

The second attribute was attraction of fishes to the reef vs. production of fishes on the rig. Respondents were told that if fishes are being attracted to the rig, it could be good for recreational divers and fishers, but could mean they become vulnerable to exploitation; but, if fishes are being produced on the rig, they would be contributing to the total regional fish production. Therefore, the attribute's options were either fishes attracted to the rig or fishes produced on the rig.

The third attribute was habitat for threatened species, which was based on findings reporting the presence of IUCN threatened species (Whale shark, Giant manta ray and Round ribbontail ray) in the vicinity of a platform jacket in the NWS (McLean et al. 2018; McLean et al. 2019). The attribute was defined as either providing habitat for these species, or not.

The fourth attribute was the type of access that could be assigned to these areas, which was based on access that are currently allowed on rigs-to-reefs programs in the USA (Bull and Love 2019). Then, the levels for this attribute were either no access (essentially establishing reserve area), access for recreational fishing, or access for recreational diving.

The fifth attribute was the long-term civil liability, which is defined by DIIS (2018, p. 31) as the "*liability for any damage or loss associated with any property left in the marine environment, or associated with other incidents arising from the title area after the end of operations (such as well leakage)*". Liability is an important issue that has not yet been resolved for rigs-to-reefs and, since potential environmental negative impacts of *in-situ* decommissioning remain limited (Shaw et al. 2018; NERA 2019), this attribute intends to account for this issue. Therefore, the options for liability were either that it lies with the oil and gas company, or the government or shared liability.

The last attribute was the payment vehicle, which was assumed to be a 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. Although there was no individual payment, respondents were told that there could be possible individual benefits such as increased State funding for health, education, or environmental issues. This mechanism has been used elsewhere e.g. Burton et al. (2012). The levels of increased royalties selected for this experiment are based on percentages of savings (between 50% and 80%) that companies attributes to rigs-to-reefs programs in the USA (Advisian 2017; Bull and Love 2019).

The survey involved 36 choice sets, blocked into six groups of six, with each choice scenario including two rigs-to-reefs options and a complete removal option. The choice scenarios were designed using the Ngene 1.1 software, which allows to efficiently arrange the attributes and their levels. The value of the S estimate reported by Ngene was 7.29. The attributes and their levels are described in Table 1 and an example of choice set is shown in Figure 2.

Table 1. 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 (AU$)	100 million, 130 million, 160 million	0

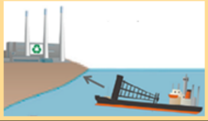
	OPTION 1 Rig-to-reef 	OPTION 2 Rig-to-reef 	OPTION 3 Complete removal 
Total fish biomass (tonnes)	0.5	1.5	Negligible
Fish attracted vs. Fish produced	Produced	Produced	
Habitat for threatened species	Yes	No	
Who can access the reef	Recreational Fishers	Recreational Divers	N/A
Future liability in case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

Figure 2. Example of choice set.

2.3 Social Licence to Operate survey

A SLO is defined by Boutilier and Thomson (2011, p. 2) as the *"community's perceptions of the acceptability of a company and its local operations"* and it can be divided into four hierarchical levels that are described in Table 2 and Figure 3. The general idea of this approach is that a higher hierarchical level of SLO will rarely be granted by a stakeholder if the lower level is not granted.

Table 2. 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. Institutionalized trust	Is 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.

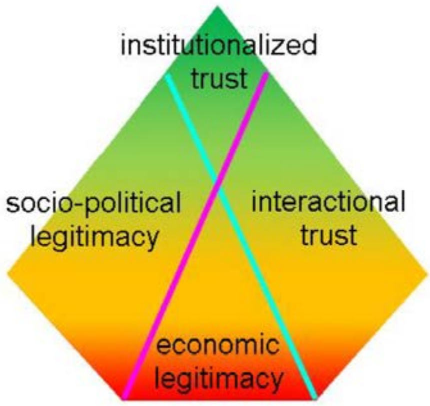


Figure 3: Levels of SLO (Source: Boutilier and Thomson 2011)

In this study, the SLO granted by the Western Australian community members to the oil and gas sector was measured in order to identify people's attitudes towards this sector using the question bank developed by Richert et al. (2015). In this questionnaire, respondents were asked a number of questions to address the four levels of SLO identified by Boutilier and Thomson (2011): economic legitimacy, interactional trust, socio-political legitimacy, and institutionalized trust. These questions were presented in the form of statements (Table 3) and respondents had to rate their agreement on a five point Likert scale, where 1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, and 5=strongly agree, thus higher values implying higher levels of SLO being granted. The questions are derived from those used by Boutilier and Thomson (201). 1 It is important to note that EL2.1–2.4 derive from the original EL2 statement used by Boutilier and Thomson (2011, p.10), which says *"we need to have the cooperation of the mine to reach our most important goals"*, for which Richert et al. (2015) specified four goals related to the environment, the economy, local communities, and future generations. As noted by Richert et al. (2015, p. 124) this specification was made in order to "*understand which issues are of particular importance to respondents before we can assess whether they believe industry is impacting negatively on those issues"*. Therefore, respondents were asked to rate the importance of the environment, the economy, local communities, and future generations on a seven point Likert scale, where 1=not at all important, 2=very unimportant, 3=somewhat important, 4=neither important nor unimportant, 5=somewhat important, 6=very important, and 7=extremely important. Then, if respondents considered those issues important (scores of five or more), the questions relating to them (EL2.1–2.4) were averaged and included in the analysis of SLO. A factor analysis was applied to the SLO questions to test if it was possible to identify a set of four factors that align with the four measures of SLO identified by Boutilier and Thomson (2011).

Finally, in order to assess if these attitudes influence peoples' choices in the DCE, the results obtained from the SLO analysis were interacted with the status quo option of the choice model i.e. the null hypothesis is that social license influences the acceptance of the R2R program as a whole, not the individual attributes of the reef.

Table 3. Statements that measure the different levels of SLO (Source: Richert et al. 2015)

Statements measuring the level of "Economic legitimacy"
EL 1: "Western Australia can economically benefit from the oil and gas sector"
EL 2.1: "Western Australia needs the cooperation of the oil and gas sector to protect the environment"
EL 2.2: "Western Australia needs the cooperation of the oil and gas sector to maintain or improve its economic performances"
EL 2.3: "Western Australia needs the cooperation of the oil and gas sector to maintain or improve the well-being of local communities"
EL 2.4: "Western Australia needs the cooperation of the oil and gas sector to guarantee the well-being of the future generation"
Statements measuring the level of "Interactional trust"
IT 1: "Companies in the oil and gas sector do what they say they will do in the media"
IT 2: "I am very satisfied by the oil and gas sector in Western Australia"
IT 3: "The presence of the oil and gas sector in Western Australia is a benefit to the Western Australian population"
IT 4: "Companies from the oil and gas sector listen to the Western Australian population concerns"
Statements measuring the level of "Socio-political legitimacy"
SPL 1: "In the long-term, the oil and gas sector makes a contribution to the well-being of Western Australia"
SPL 2: "The oil and gas sector in Western Australia treats everyone fairly"
SPL 3: "The oil and gas sector respects the Western Australian population way of doing things"
SPL 4: "The Western Australian population and the oil and gas sector have a similar vision for the future of Western Australia"
Statements measuring the level of "Institutionalized trust"
InstT 1: "Companies of the oil and gas sector give more support to those it negatively affects"
InstT 2: "The oil and gas sector shares decision-making with the Western Australian government"
InstT 3: "The oil and gas sector takes into account the interests of the Western Australian population"
InstT 4: "The oil and gas sector is concerned about the Western Australian population"
InstT 5: "Companies of the oil and gas sector openly share information that is relevant to the Western Australian population"

2.4 Survey administration and additional questions

Initially, the questionnaire was distributed to a focus-group of seven people in order to collect comments and suggestions that could improve the quality of the final survey. The final version was distributed by a market research company to a random sample (stratified by age and gender) from the Perth metropolitan area in March 2020. The selection of Perth as a sample of the Western Australia community stems from the need to measure the values that may be hold for the environmental goods and services by those who may not be directly affected by the operations of the oil and gas companies, i.e. the "existence" values.

The first part of the questionnaire consisted of the SLO questions, as well as attitudinal questions regarding involvement with the oil and gas sector or environmental groups, previous knowledge about rigs-to-reefs, and attitudes towards recreational fishing and diving. Afterwards, respondents were provided with background information regarding offshore oil and gas decommissioning and rigs-to-reefs, a description of the attributes and levels of each policy scenario, and the choice sets. In addition, debriefing questions were asked to check for any specific problems that could have been faced by respondents when answering the choice set. The final section of the survey consisted of questions related to respondent's socio-demographic information (age, gender, educational level and income). Overall, the survey consisted of five sections, as shown in Table 4. The full survey is reported in Appendix A.

Table 4. Summary of survey sections.

Survey sections
1. SLO and attitudinal questions
2. Background information on offshore oil and gas decommissioning and rigs-to-reefs
3. Description of the attributes and choice experiment questions
4. Debriefing questions about the choice task
5. Socio-demographic information about the respondents

3. Results

3.1. Sample characteristics

The survey was completed by a total of 431 respondents, each of them completing six choice sets. The respondents that completed the survey too fast, in less than five minutes, were excluded from the data set, leaving a final sample of 392 respondents. A common feature of DCE is the presence of respondents who use heuristics, rather than the compensatory behaviour implied by (3). A common form of this is 'protest' behaviour, where respondents adopt a response to the questions that implies they are rejecting some aspect of the framing of the questions. We identify this as respondents who always selected the 'status quo' option in all 6 questions. These were excluded from the analysis of the choice data, although their answers were retained in the SLO and descriptive statistics. This group of respondents represented 9.4% of the final sample and explicitly objected the idea of leaving oil and gas rigs in the sea, as reported in the debriefing questions.

Overall, respondents in the sample reflected the demographic structure of the Western Australia population (Table 5).

Table 5. Demographic characteristics of survey respondents.

Demographics	Sample (%)	Western Australia population (%)
Gender		
Male	51	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)

3.2 Social Licence to Operate

The SLO results were obtained following the same analysis as Richert et al. (2015). First, a single average measure was generated from questions EL2.1–2.4 (Table 3), with answers to a question only being retained if the respondent specified that the environment, the economy, the local communities and the future generations were "somewhat important", "important" or "extremely important" to them. Similar to Richert et al. (2015) results, the analysis showed that a large majority of the respondents considered that all the issues were important (Table 6).

Table 6. Percentage of the respondents who found important the environment, the economy, the local communities, and the future generations.

Environment	Economy	Local Communities	Future Generations
85.72	86.22	82.91	85.72

Then, using the composite variable for EL2 along with the responses to the other 14 SLO questions, an exploratory factor analysis was used, applying Kaiser's criterion to define the significant factors, i.e. the factors with an eigenvalue greater than one (Kaiser 1960). The factor analysis revealed the same results as those obtained by Richert et al. (2015), with the same questions loaded on the same two factors: Factor 1, containing the two questions that evaluate the economic legitimacy of the oil and gas sector in Western Australia (EL1 and EL2), along with one question of interactional trust (IT3) and one question of socio-political legitimacy (SPL1); and Factor 2, containing the remaining questions, as shown in Table 7. With these results, we created a measure of the "Extended economic legitimacy" by averaging the score for the variables that were grouped within Factor 1, and a measure of "Social legitimacy" by averaging the score of the remaining variables that were grouped within Factor 2. In addition, the Cronbach alpha coefficient of these two measures was calculated in order to estimate their internal consistency (Cronbach 1951). The results showed a value of the Cronbach alpha coefficient of 0.84 for the "Extended economic legitimacy" and 0.95 for the "Social legitimacy", which confirms that it is acceptable to treat the questions within each of these categories, as a value of this coefficient higher than 0.7 indicates that the questions measure a single construct (Nunnally and Bernstein 1994).

Table 7. Estimated weights for significant factors.

Level of SLO	Variable	Factor 1	Factor 2
Economic legitimacy	el1	0.6975	
	el2	0.4867	
Interactional trust	it1		0.4702
	it2		0.4257
	it3	0.7699	
	it4		0.6601
Socio-political legitimacy	spl1	0.6613	
	spl2		0.8025
	spl3		0.8247
	spl4		0.7778
Institutional trust	inst1		0.6217
	inst2		0.5574
	inst3		0.7861
	inst4		0.8167
	inst5		0.7855

Table 8 reports a summary and the relative distributions of the two measures of SLO. As it can be seen, respondents held an average score of 3.88 for "Extended economic legitimacy", indicating that they tended to agree that the oil and gas sector contributes to the economy of Western Australia (recall that in a range from one to five, higher scores indicate a higher SLO), whereas they neither agree nor disagree on average (mean = 3.15) with the measure of "Social legitimacy".

Table 8. Summary of the "Extended economic legitimacy" and the "Social legitimacy" measures.

Score	Extended economic legitimacy (%)	Social legitimacy (%)
1 - 1.99	2	7
2 - 2.99	7	28
3 - 3.99	39	48
4 - 5	52	17
Mean	3.88	3.15
Std. dev.	0.734	0.805
n	392	392

However, the sample mean score only detects general perceptions. To analyse the perceptions at a respondent level, Boutilier and Thomson (2011) suggests that one should rarely see a score for the higher levels of SLO (here "Social legitimacy") exceeding that of the lower (here "Extended economic legitimacy"), as economic legitimacy has to be achieved before social legitimacy is granted. Also, if the lowest level of SLO is granted, it will not necessary guarantee the achievement of the following level. This can be confirmed with the scatter plot of individual scores for the measures of "Extended economic legitimacy" and "Social legitimacy" presented in Figure 4. Note that this is the same relationship as found by Richert et al. (2015, p.126), *"the fact that the majority of points lie above the 45° line confirms that each respondent generally held a higher value for "Extended economic legitimacy" than for "Social legitimacy"*.

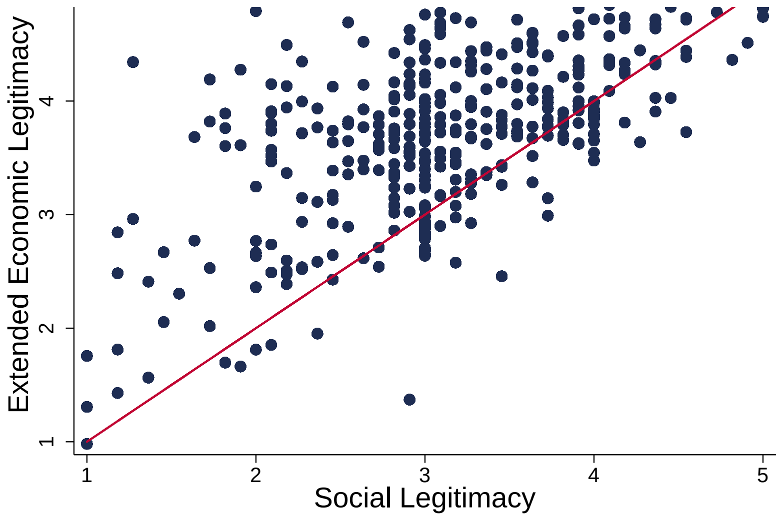


Figure 4. Scatter plot of individual scores for “Extended economic legitimacy” vs. “Social legitimacy”.

3.3 Attitudinal questions

Prior to answering the choice sets, respondents were asked about their awareness of the process of “rigs-to-reefs”. 58% were not aware of rigs-to-reefs before taking the survey, whereas 30% of them had some degree of awareness. Therefore, it is worth highlighting that for more than a half of the respondents, their understanding of decommissioning options, and hence their choices, were conditioned by the information and context provided by the framing of the DCE. In addition, respondents were asked a set of questions regarding their involvement in recreational fishing and diving. The majority of the respondents (78%) answered ‘yes’ to the question whether they have ever been fishing, whereas only 35% of them answered ‘yes’ to the question whether they have ever been diving (Table 9). After the choice sets were completed, respondents were asked which of the attributes that were used to describe the decommissioning options were relevant to them. The results revealed that each attribute was relevant to 41 - 63% of the respondents (Table 9), which might be indicating that they were very selective in their choices.

Table 9. Attitudinal questions (% of respondents answering 'Yes').

Questions	Yes (%)	Variable name
Have you ever been		
Fishing?	78	FISH
Diving?	35	DIV
Which attributes used to describe the options were relevant to you?		
Habitat for threatened species	63	ATTHAB
Total fish biomass	43	ATTBIO
Fish attracted vs. fish produced	41	ATTPROD
Access to the reef	50	ACCDIVER/ACCFISHER
Future liability	55	LIABGOVT/LIABJOINT
Revenue for the State budget	48	ATTREV

3.4 Choice experiment models

In order to estimate the relative value held by the respondents for the different attributes of the rig-to-reef option, an initial conditional logit model focussed only on attributes was applied, while in a second model the interactions with attitudinal questions were added. Table 10 reports the description of the variables used in both models.

Table 10. Description of variables used in the models.

	Description
Attributes	
SQ	Status Quo (complete removal of rigs)
HAB	Habitat for threatened species (1=Yes, 0=No)
BIO	Fish biomass
PROD	Fish production (1=Fish Produced, 0=Fish attracted)
ACCDIVER	Access for recreational divers (1=Access, 0=No access)
ACCFISHER	Access for recreational fishers (1=Access, 0=No access)
LIABGOVT	Liability lies with the Government (1=Liable, 0=Company liable)
LIABJOINT	Liability shared between Government and company (1=Liable, 0= Company liable)
REV	Revenue for the State budget
Interactions	
SQ*EEL	Status quo*Extended economic legitimacy
HAB*ATTHAB	Habitat for threatened species*Attended to habitat for threatened species
BIO*ATTBIO	Fish biomass*Attended to fish biomass
PROD* ATTPROD	Fish production*Attended to fish production
ACCDIVER*DIV	Access for recreational divers*Divers
ACCFISHER*FISH	Access for recreational fishers*Fishers
REV*ATTREV	Revenue for the State budget*Attended to revenue
REV*NOATTREV	Revenue for the State budget*Not attended to revenue

In the initial model, reported in Table 11, the coefficients of habitat for threatened species (HAB), fish biomass (BIO) and revenue for the State budget (REV) were positive, implying that respondents preferred the provision of habitat for threatened species, increased fish biomass and increased revenue for the State budget rather than other options. Conversely, the status quo scenario (SQ) and government liability (LIABGOVT) affected choices in a negative way, suggesting that respondents preferred the structure to be left in the sea for reefing purposes, but without the government -and consequently the taxpayer- being liable in case of any future environmental damage occurring as a result of this decision. This model detected clear preferences for these attributes given that their coefficients were significant, but did not detect any significant effect of fish production (PROD), access for recreational divers (ACCDIVER), access for recreational fishers (ACCFISHER) and shared liability between the government and the company (LIABJOINT).

Table 11. Conditional logit model, attributes only.

Choi	Coef.	Std. Err.	P>|z|	95% Conf. Interval	
SQ	-0.997	0.219	0.000	-1.426	-0.568
HAB	0.583	0.091	0.000	0.404	0.762
BIO	0.222	0.091	0.015	0.042	0.401
PROD	0.155	0.104	0.135	-0.048	0.359
ACCDIVER	0.183	0.108	0.090	-0.028	0.394
ACCFISHER	0.041	0.065	0.527	-0.086	0.169
LIABGOVT	-0.127	0.083	0.000	-1.017	-0.603
LIABJOINT	-0.81	0.106	0.126	-0.289	0.036
REV	0.0025	0.0009	0.008	0.001	0.004

Number of observations = 6,354; LR chi2 (9) = 817.38; Pseudo R2 = 0.1756; Log likelihood = -1918.17

In the full model, which is reported in Table 12 and includes the interactions between the attributes and the attitudinal questions, it was possible to detect significant effects for most of the interactions. A negative and significant effect in the interaction between the status quo and the economic legitimacy (SQ*EEL) was noticed, indicating that those respondents that tended to grant economic legitimacy to the oil and gas sector in Western Australia, preferred the structure to be left in the sea for reefing purposes. Those who did not grant economic legitimacy were less supportive of the idea of leaving the rig as a reef. Therefore, a lower score in economic legitimacy may be leading to a higher utility associated with the complete removal option compared to that generated by the rigs-to-reefs option. Social legitimacy was also interacted with the SQ, but it did not have any significant impact in the model.

A positive and significant effect in the interaction of habitat for threatened species, fish biomass and fish production were observed, with the answer of the respondents stating that these attributes were relevant to them (HAB*ATTHAB, BIO*ATTBIO and PROD*ATTPROD). This suggests that these respondents held higher values for the provision of habitat for threatened species, increased fish biomass, and production of fishes on the rigs, than those who did not consider these attributes as relevant to them (HAB, BIO and PROD). These results are consistent with literature related to attribute non-attendance (Kragt 2013). A similar positive and significant effect was observed with the access to the rig-to-reef for recreational divers and fishers: those who answered ‘yes’ to the questions of whether they have ever been diving and fishing i.e. divers and fishers, preferred the rig-to-reef to be accessible for recreational divers and recreational fishers (ACCDIVER*DIV and ACCFISHER*FISH), respectively, whereas those who had never been diving were indifferent to the idea of the rig-to-reef being accessible for recreational divers (ACCDIVER). However, those respondents that had never been fishing revealed a significant reduction in the utility associated with the rig-to-reef being accessible by recreational fishers (ACCFISHER), which can be noticed by the negative and significant value of the attribute's coefficient. Finally, a significant and positive effect was detected for the interaction between the increased revenue for the State budget and the respondents who considered this attribute to be relevant to them (REV*ATTREV). This implies that those who paid attention to this attribute preferred an increased revenue for the State budget, whereas those who did not pay attention to revenue (REV*NOATTREV) were indifferent to this variable. The liability attributes in this model (LIABGOVT and LIABJOINT) revealed similar results to those obtained in the initial model: government liability affected choices in a negative way with a significant reduction of the utility associated to it. A shared liability between the Government and company was significant only at 10% i.e. was seen as almost equivalent to company liability. These attributes were also interacted with the attitudinal questions, but they were not included in the model as they did not add any substantial improvement to the model. Also, all the variables were interacted with attitudes towards the environment, involvement with the oil and gas sector, involvement with environmental NGOs, and awareness of rigs-to-reefs, but none had a significant effect in the model.

Overall, the fit of the full conditional logit model to the data was better than in the initial model as shown by the higher pseudo R2 (0.1948) and the higher log likelihood (-1873.507).

Table 12. Conditional logit model, full model.

Choi	Coef.	Std. Err.	P>|z|	95% Conf. Interval	
SQ	0.583	0.433	0.179	-0.267	1.432
HAB	0.180	0.117	0.124	-0.050	0.409
BIO	0.087	0.104	0.404	-0.117	0.290
PROD	-0.011	0.122	0.925	-0.251	0.228
ACCDIVER	0.037	0.122	0.764	-0.203	0.277
ACCFISHER	-0.329	0.122	0.007	-0.567	-0.090
LIABGOVT	-0.138	0.084	0.000	-0.301	0.026
LIABJOINT	-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 chi2 (9) = 906.71; Pseudo R2 = 0.1948; Log likelihood = -1873.5072

3.5 Partworths

Partworths, also called implicit prices, were estimated for a change in the non-monetary attributes using equation (4). In this study, the partworths are defined as the amount of money the respondent - who attended to the revenue attribute - is willing to pay in forgone tax revenue for a unit increase in the level of an attribute. In the initial model (Table 13), the estimated part-worth for the provision of habitat for threatened species was significant and positive, suggesting that respondents are willing to pay AU$ 233.28 million in forgone tax revenue if a rig-to-reef provides habitat for threatened species. Conversely, the estimated part-worth for government liability was significant and negative, indicating that respondents would require a compensation of AU$ 324.22 million in revenue to the State budget in order to let the government, i.e. the taxpayer, to be liable in case of any future environmental damage occurring as a result of leaving the rig in the sea. On average, respondents' willingness to be compensated for the complete removal of the structures or a shared liability between the government and the company, as well as respondents' willingness to pay for increased fish biomass, production of fishes on the rig or access for recreational fishers and divers, were not significant.

Table 13. Partworths in the initial model (AU$ million per decommissioned rig).

	Coef.	Std. Err.	P>|z|	95% Conf. Interval	
SQ	-398.97	213.386	0.062	-817.200	19.259
HAB	233.28	95.969	0.015	45.188	421.382
BIO	88.67	49.628	0.074	-8.597	185.942
PROD	62.14	48.182	0.197	-32.298	156.572
ACCDIVER	73.13	51.204	0.153	-27.232	173.484
ACCFISHER	16.46	26.432	0.533	-35.346	68.269
LIABGOVT	-324.22	129.961	0.013	-578.941	-69.504
LIABJOINT	-50.68	38.313	0.186	-125.771	24.411

In the full model, which includes the interactions between the attributes and the attitudinal questions, a significant heterogeneity in values is identified. The estimated partworths (in millions) for the provision of habitat for threatened species (AU$ 247.42), increased fish biomass (AU$ 119.19) and production of fishes on the rig (AU$ 119.99) were significant and positive for those respondents who considered these attributes to be relevant; thus, revealing a significant WTP in terms of forgone tax revenue. These were not significant for those who not consider these attributes to be relevant. Likewise, the estimated part-worth for divers being allowed to access the rig-to-reef was significant and positive if the respondent was a diver (AU$ 148.26), but not for non-divers. Conversely, the part-worth for the access of fishers to the rig-to-reef was significant and negative for respondents that were not fishers (AU$ -101.76), i.e. for non-fishers, allowing access to the reef reduced utility compared to it being a closed protected area. For fishers, having access to the reef the WTP was also positive, but only significant at 10%. This low effect in WTP may be due to a very broad definition of what a fisher is.

The implicit price for government liability was again significant and negative (AU$ -252.46); thus, requiring compensation for the utility reduction attached to this outcome. Additionally, the implicit prices associated with the interaction between the status quo and the different levels of economic legitimacy granted to the oil and gas sector in Western Australia was calculated. The results revealed that the value attached to the reef being removed gets higher for respondents granting higher levels of economic legitimacy (AU$ 350.66 - AU$ 483.45 million). However, it is worth highlighting that these numbers may not very robust given that they are outside of the range for the revenue used in the survey. They should only be used as an indicator that respondents granting higher degree of economic legitimacy to the oil and gas sector in Western Australia, have seldom chosen the status quo option. Likewise, those granting lower degree of economic legitimacy, may have chosen the option of complete removal more often.

Table 14. Partworths in the full model (AU$ million per decommissioned rig).

	Coef.	Std. Err.	P>|z|	95% Conf. Interval	
SQ	180.51	134.884	0.181	-83.863	444.876
HAB	55.74	40.706	0.171	-24.044	135.552
BIO	26.84	33.262	0.420	-38.351	92.035
PROD	-3.56	37.818	0.925	-77.682	70.563
ACCDIVER	11.41	38.139	0.765	-63.344	86.158
ACCFISHER	-101.76	51.666	0.049	-203.025	-.49679
LIABGOVT	-252.46	90.806	0.005	-430.439	-74.487
LIABJOINT	-42.64	29.630	0.150	-100.715	15.434
Attributes + interactions with attitudinal questions					
HAB+ATTHAB	247.42	88.795	0.005	73.390	421.461
BIO+ATTBIO	119.19	52.714	0.024	15.873	222.510
PROD+ATTPROD	119.99	58.701	0.041	4.943	235.046
ACCDIVER + DIVACCDIVER	148.26	68.175	0.030	14.642	281.886
ACCFISHER + FISHACCFISHER	50.04	27.420	0.068	-3.701	103.784
Status Quo + interactions with different levels of economic legitimacy					
SQ+SQEEL*1	47.71	105.429	0.651	-158.921	254.352
SQ+SQEEL*2	-85.07	100.693	0.398	-282.431	112.280
SQ+SQEEL*3	-217.87	123.555	0.078	-460.030	24.297
SQ+SQEEL*4	-350.66	162.774	0.031	-669.688	-31.627
SQ+SQEEL*5	-483.45	209.350	0.021	-893.766	-73.130

3.6 Probabilities

Although partworths are conventionally reported in such DCE studies, in the current context what may be of more interest is the degree to which different types of reefs are acceptable to respondents, as well as the influence that each attribute may have on respondents' choices. Therefore, we used equation (3) to create hypothetical scenarios of rig-to-reef vs. complete removal and worked out what is the probability that a respondent would accept the reef option. Each hypothetical scenario was constructed by varying the levels of the attributes of the reef one at a time and, because of the interaction of the status quo with the extended economic legitimacy (EEL), we obtained a different probability of choosing the rig-to-reef for each one of the 5 levels of EEL. Then, we compared those probabilities with the probabilities obtained for a ‘base reef’ (Table 15).

The probabilities of the ‘base reef’, shown in Table 15, row 1, 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 AU$100 million 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 the highest level of EEL to the oil and gas sector, to 0.51 for someone that does not grant EEL. Then, the level of the attribute habitat for endangered species was changed in order to obtain the probabilities of choosing a rig-to-reef with this attribute, which is shown in Table 15, row 2a. Compared to the base reef, it would increase the chance of choosing the reef by 0.19 for someone that does not grant EEL, but it would increase by just 0.08 for someone with the highest degree of that. In this case, the probability also decreases with the level of EEL, from 0.93 to 0.70, which shows the impact that the attribute may have on the decision. A similar trend was observed when adding the fish biomass attribute to the base reef (Table 15, row 2b), revealing that higher amounts of fish biomass will result in higher probabilities of the reef being chosen compared to the base reef. Also, the probabilities of choosing the reef decreases significantly as the degree of EEL decreases. A similar situation was observed for fish production (Table 15, row 2c).

For the access to the reef for divers (Table 15, rows 3a and 3b), 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 (Table 15, row 4a) 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 (Table 15, row 4b) revealed similar results to those obtained with the other numerical variable in the experiment, fish biomass. Thus, 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 15. Probabilities of choosing the rig-to-reef option depending on different levels of attributes and degree of economic legitimacy.

Attributes	Levels of economic legitimacy				
	1	2	3	4	5
1. Base reef	0.51	0.62	0.71	0.79	0.85
2. Biological					
a. Habitat & attend to habitat	0.70	0.78	0.85	0.89	0.93
b. Fish biomass (tonnes) & attend to biomass					
0.5	0.55	0.65	0.74	0.81	0.87
1	0.60	0.69	0.78	0.84	0.89
1.5	0.64	0.73	0.81	0.87	0.91
c. Fish production & attend to fish production	0.61	0.70	0.78	0.85	0.90
3. Access to the reef					
a. For divers, if					
Not a diver	0.52	0.63	0.72	0.80	0.86
Diver	0.63	0.72	0.80	0.86	0.90
b. For fishers, if					
Not a fisher	0.43	0.54	0.64	0.73	0.81
Fisher	0.55	0.65	0.74	0.82	0.87
4. Socio-economic					
a. Liability					
Government	0.32	0.42	0.52	0.63	0.72
Shared	0.48	0.58	0.68	0.77	0.84
b. Revenue (AU$ million) & attend to revenue					
100	0.55	0.65	0.74	0.82	0.87
130	0.58	0.68	0.76	0.83	0.88
160	0.60	0.70	0.78	0.84	0.89

4. Discussion and conclusions

The results of the DCE models revealed respondents' preferences for rigs-to-reefs as an alternative option to complete removal of offshore oil and gas infrastructure, given a set of potential ecological and socio-economic characteristics that could be part of a rigs-to-reefs policy. However, recall that 9.4% of the respondents objected the idea of leaving oil and gas rigs in the sea; hence, putting higher values on a clear seabed (Ekins et al. 2006).

We confirmed our hypothesis that the degree of SLO granted by respondents to the oil and gas sector in Western Australia (at least in terms of extended economic legitimacy), influences their attitudes towards rigs-to-reefs, with respondents being less likely to support a rigs-to-reefs policy if they grant a lower SLO to the industry. Similar results were found by Burton et al. (2017) in a study measuring community acceptance of biodiversity offsets in Western Australia.

Regarding the values held for different attributes of a potential rigs-to-reefs policy, we found that respondents attached large values to the habitat that these structures could provide for threatened species, with a significant and positive WTP. These results may be explained not only because of the value attached to threatened species as such, but also because the threatened species indicated in this study, i.e. Giant manta ray and Whale shark, may also be charismatic or 'iconic' species, which according to previous studies (Jacobsen et al. 2008; Morse-Jones et al. 2014; Colleony et al. 2017) is a significant determinant of preferences and could result in very high values.

The results for the other two ecological attributes revealed that respondents held, on average, a positive value for higher amounts of fish biomass on the rig, whereas the possible production of fishes on the rig -as opposed to the attraction of fishes- had a significant value for those who considered this attribute to be relevant. Also, respondents who considered these attributes to be relevant, showed a significant and positive WTP. Although previous work has identified values for ecological attributes of artificial reefs (Borger et al. 2015), we believe that this is the first time that the differentiation in values between fishes being produced on the rig vs. fishes being attracted has been identified.

With respect to the accessibility to the rig-to-reef, respondents that were identified as divers and fishers, attached large values to the possibility of the artificial reef being accessible for divers and fishers, with divers revealing a significant and positive WTP. These results are in line with previous studies (Roberts et al. 1985; Oh et al. 2008; McGurrin and Fedler 1989) indicating that rigs-to-reefs are highly valued by scuba-divers and recreational fishers. However, those respondents that were identified as non-fishers revealed a significant reduction of the utility associated to the reefs being accessible for recreational fishers. A possible explanation for this result is that fishing, as an extractive activity, could be reducing the value that respondents hold for the ecological attributes; hence, they might prefer the artificial reef to be used for conservation purposes.

Respondents expect a strong welfare loss if the liability for any possible environmental damage lies with the Government, as shown by the significant and negative WTP. Therefore, these results show that taxpayers would not be willing to accept responsibility, including meeting the associated costs, if an environmental incident occurred as a result of leaving the oil and gas rigs in the sea (DIIS 2018).

With respect to the revenue component, the results showed that respondents held a positive value for the money that could be potentially paid to the State budget by oil and gas companies if not undertaking complete removal of infrastructure. This could be explained by the fact that respondents were told that this extra revenue could be used for funding for health, education, or other environmental issues (Burton et al. 2012).

Finally, the probabilities indicated that rigs-to-reefs attributes such as habitat for threatened species, increased fish biomass, production of fishes on the rig, increased revenue to the State budget and access for recreational divers or fishers when the respondent is a diver, non-diver or fisher, would increase the probability that a respondent who attends to those attributes chooses the reef option compared with a reef that does not provide those benefits. Conversely, the probability of a reef being chosen by a respondent decreases if it involves Government liability, shared liability or access for fishers in the case that the respondent is not a fisher.

4.1 Policy implications and suggestions for further research

The findings of this study are of primary relevance to decision processes because they identify the preferences and values that Western Australia community members may hold for possible outcomes of a rigs-to-reefs policy. Although respondents supported rigs-to-reefs in the majority of the scenarios presented in the survey, 9.4% of them opposed any reefing; hence, indicating that there is not an overall support for this policy. Given that there is still limited information and uncertainty regarding the outcomes of rigs-to-reefs, these findings could contribute to identify relevant areas for further research on the value that the Western Australian community may attach to them. For instance, it would be valuable to increase research on how these structures are being used by threatened species, or if fishes are being produced on the rigs.

Also, it is worth mentioning some improvements that could be done within this research. It was noted that respondents were very selective in their choices regarding the attributes they considered relevant. Therefore, the use of models that account for heterogeneity in preferences, such as latent class models, could improve the results. In addition, interactions between attributes and demographic variables such as gender, age and income of the respondents, could also be useful.

There are a number of ways in which the design of the DCE could be improved. For instance, rigs to reefs providing habitat for invasive species could be included as an attribute in future studies. Also, it is possible that the value calculated for the savings that companies would be making from not undertaking complete removal (AU$200 million) could have been overestimated given that it was derived from a general estimation (DIIS 2018); therefore, having access to more accurate estimates would be useful for future studies. In addition, the sample was relatively small and limited to the Perth metropolitan area in Western Australia; hence, the use of a bigger and more representative national sample would be valuable. Finally, it is worth highlighting that respondents' preferences may be based on a limited knowledge of the topic. Therefore, it is suggested to consider the results of this study taking into account this limitation.

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Appendix A: PDF version of online survey instrument

PARTICIPANT INFORMATION

University of Western Australia Research Project

“Community acceptance of Rigs-to-Reefs in Western Australia”

Human ethics reference number RA/4/20/5924

Thank you for considering participation in this research project, involving completion of an online survey about attitudes towards the management of decommissioned oil and gas platforms in the marine environment.

This project is part of a master’s research project, being undertaken by Veronica Recondo, supervised by Dr Michael Burton, and Dr Johanna Zimmerhackel, from the Faculty of Science, University of Western Australia.

What is the project about?
The aim of the study is to understand the public's perceptions of the oil and gas industry, and what the preferred methods are of disposing of oil and gas infrastructure at the end of its useful life.

What does participation involve?
Participation in the survey means that you will be asked to complete an online survey. You will be provided with information about possible hypothetical management of oil and gas infrastructure, and asked to indicate which you think is better. It should take no more than 10-15 minutes to complete.

Voluntary Participation and Withdrawal from the Study
Your participation will be on a voluntary basis and you can withdraw your participation at any stage of research without prejudice. If you withdraw before completing the survey, your answers will be discarded. If after completing the survey you later wish to withdraw your answers, this may not be possible, as the data is anonymised.

Your privacy
Your information will be anonymously stored online in the questionnaire software initially and later on the researcher’s laptop and finally in University of Western Australia (UWA) data backup system for at least seven years. This information will be kept strictly confidential and will not be made available to other people.

Possible Benefits
This research project will identify community preferences for different forms of management of offshore oil and gas infrastructure. There is ongoing debate on how best to achieve this, and it is important that the publics preferences are represented.

Possible Risks and Risk Management Plan
There are no foreseeable risks and potential harm associated on providing personal information and opinions. If any aspects of this research project distresses you, you can contact me at the above address or the UWA Human Research Ethics office at the below address.

Contacts
if you have any questions with any aspects of this interview, please feel free to contact me at my work phone number (+61864882531) or by email (michael.burton@uwa.edu.au).

Sincerely,

Dr. Michael Burton, Chief Investigator

Approval to conduct this research has been provided by The University of Western Australia (ethics reference number: RA/4/20/5924), in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time. In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Ethics office at UWA on (08) 6488 4703 or by emailing to humanethics@uwa.edu.au.

If you wish you can keep a copy of the Participant information

What is your gender?

- Male
- Female

Which of the following age brackets applies to you?

- under 18
- 18-30
- 31-45
- 46-60
- 61-75
- Over 75

PART 1: We would like to start with some questions about your perception of the environment, and the ‹ and gas industry in Western Australia.

Does the state of the environment concern you?

- Not at all
- Not much
- I am not sure
- A little
- A lot

Are you involved or have ever been involved with any environmental organisation (such as an NGO)?

- Yes
- No

Are you working or have ever worked in the oil and gas industry?

- Yes
- No

How much do you know about the oil and gas sector in Australia?

- I know nothing about it
- I only know the names of the companies
- I am roughly aware of its activities
- I am aware of its activities: I know quite precisely what the oil and gas companies do
- I am well aware of its activities: I know what the oil and gas companies do and how their activities interact with people and with the natural environment

In your opinion, how does the oil and gas sector affect the West Australian economy?

- It has a very negative impact on the economy
- It has a negative impact on the economy
- Its impact on the economy is neither negative nor positive
- It has a positive impact on the economy
- It has a very positive impact on the economy
- I don't know

In your opinion, how does the oil and gas sector affect the West Australian natural environment?

- It has a very negative impact on the natural environment
- It has a negative impact on the natural environment
- Its impact on the natural environment is neither negative nor positive
- It has a positive impact on the natural environment
- It has a very positive impact on the natural environment
- I don't know

In your opinion, how does the oil and gas sector affect West Australian local communities?

- It has a very negative impact on local communities
- It has a negative impact on local communities
- Its impact on local communities is neither negative nor positive
- It has a positive impact on local communities
- It has a very positive impact on local communities
- I don't know

In your opinion, how will current activities of the oil and gas sector affect the well-being of future generations in Western Australia?

- They will very negatively impact on the well-being of future generations
- They will negatively impact on the well-being of future generations
- Their impact on the well-being of future generations will be neither negative nor positive
- They will positively impact the well-being of future generations
- They will very positively impact the well-being of future generations
- I don't know

How important is the well-being of the following to you:

	Not at all Important	Very Unimportant	Somewhat Unimportant	Neither Important nor Unimportant	Somewhat Important	Very Important	Extremely Important
Environment	○	○	○	○	○	○	○
Economy	○	○	○	○	○	○	○
Local communities	○	○	○	○	○	○	○
Future generations	○	○	○	○	○	○	○

Please state whether you agree/disagree with the following statements:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Western Australia can economically benefit from the oil and gas sector	○	○	○	○	○
Western Australia needs the cooperation of the oil and gas sector to protect the environment	○	○	○	○	○
Western Australia needs the cooperation of the oil and gas sector to maintain or improve its economic performances	○	○	○	○	○
Western Australia needs the cooperation of the oil and gas sector to maintain or improve the well-being of local communities	○	○	○	○	○
Western Australia needs the cooperation of the oil and gas sector to guarantee the well-being of future generations	○	○	○	○	○
Companies in the oil and gas sector do what they say they will do in the media	○	○	○	○	○
I am very satisfied with the oil and gas sector in Western Australia	○	○	○	○	○

Please state whether you agree/disagree with the following statements:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
The presence of the oil and gas sector in Western Australia is a benefit to the Western Australian population					
Companies from the oil and gas sector listen to the Western Australian population concerns					
In the long-term, the oil and gas sector makes a contribution to the well-being of Western Australia					
In the long term, the oil and gas sector makes a positive contribution to environmental outcomes in Western Australia					
The oil and gas sector in Western Australia treats everyone fairly					
The oil and gas sector respects the Western Australian population way of doing things					
The Western Australian population and the oil and gas sector have a similar vision for the future of Western Australia					

Please state whether you agree/disagree with the following statements:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
The presence of the oil and gas sector in Western Australia is a benefit to the Western Australia environment					
Companies of the oil and gas sector give more support to those it negatively affects					
The oil and gas sector shares decision-making with the Western Australian government					
The oil and gas sector takes into account the interests of the Western Australian population					
The oil and gas sector is concerned about the Western Australian population					
The oil and gas sector is concerned about the Western Australian environment					
Companies of the oil and gas sector openly share information that is relevant to the Western Australian population					

In the rest of the survey, we are going to focus on a particular issue that is important for the oil and gas industry and regulators in Western Australia: what to do with the oil and gas rigs at the end of their productive lives?

The purpose of this survey is to determine the West Australian community's preferences regarding the creation of artificial reefs as an alternative option to complete removal of offshore oil and gas platforms, also known as Rigs-to-Reefs.

The rest of the survey comprises of 3 main parts:

PART 2: You will be given some background information on offshore oil and gas decommissioning and rigs-to-reefs.

PART 3: We will describe a hypothetical decommissioning scenario and you will be presented with three possible options. Each option will be described by a set of characteristics and you will be asked to choose your most preferred.

PART 4: We will ask some questions about you, to make sure we have a representative sample of the West Australian community.

PART 2:

Some **offshore oil and gas platforms** in Western Australia are reaching the end of their lifecycle which means that they must be **decommissioned**.

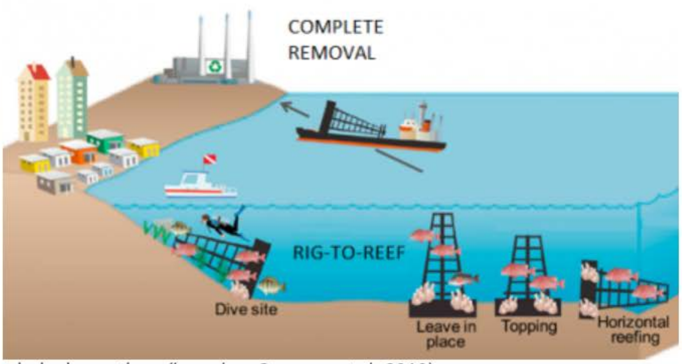
Decommissioning is the process of removing or otherwise satisfactorily dealing with offshore petroleum structures at the end of their useful life.

Complete removal of the structure from the sea is required under current decommissioning regulations when they are no longer productive.

This would return the seabed as close as possible to its natural condition.

The removed structures would be brought onshore for recovering and recycling of the steel, as well as disposing to landfill those parts that cannot be recycled.

Rigs-to-reefs is an alternative option currently considered by regulators, such as leaving the majority of the platforms in the sea so they can become artificial reefs.



Images: Offshore oil platform; Decommissioning options (based on Sommer et al. 2019).

These rigs-to-reefs could **provide habitat** (food, shelter, protection) for many marine species such as sponges, anemones, clams, sea stars and fishes. They could also contribute to **increase marine species diversity** and could be used for recreational activities such as **fishing and diving**.

Images: Rigs-to-reefs (courtesy of Greg Boland; capeandislands.org; guyharveymagazine.com).

Corrosion on structures left in the sea may occur, resulting in the release of contaminants to the marine environment.

Complete removal will eliminate this possibility, although it could also increase the risk of seabed disturbance and re-suspension of contaminants during removal.

Before this survey, how familiar were you with the idea of "rigs-to-reefs"?

- I didn't know what "rigs-to-reefs" was
- I had a vague idea of what "rigs-to-reefs" was
- I knew what was meant by "rigs-to-reefs"

Have you ever been fishing?

- No, never
- Yes, but I rarely go
- Yes, I go about once a year
- Yes, I go monthly
- Yes, I go weekly

Have you ever been scuba or free diving?

- No, never
- Yes, but I rarely go
- Yes, I go about once a year
- Yes, I go monthly
- Yes, I go weekly

PART 3:

Now we'd like you to think about a **hypothetical scenario** in which there is a petroleum platform that needs to be decommissioned in the North West Shelf of Western Australia and there are three possible options from which you will have to choose:

OPTIONS 1 and 2: Rig-to-reef, which involve leaving the platform (entirely or parts of it) in the sea for reefing purposes. Because there are different ways the platform could be decommissioned, the two options will have different outcomes.

OPTION 3: Complete removal of the platform from the sea, which is the current regulatory requirement and involves leaving a clear seabed.

OPTION 1 Rig-to-reef	OPTION 2 Rig-to-reef	OPTION 3 Complete removal
		

Each option will be characterised by the following 6 features:

1. Total fish biomass.

2. Attraction of fish to the rigs vs. production of fish on the rigs.

3. Habitat for threatened species.

4. Who can access the reef.

5. Future liability in case of any environmental damage occurring.

6. Amount of money paid to the State budget by the company.

We are now going to describe each feature:

FEATURE 1: Total fish biomass

Total fish biomass is the **total weight of fishes** that can be found around a rig. It is a measure of the overall amount of fish that may be using the reef as habitat.

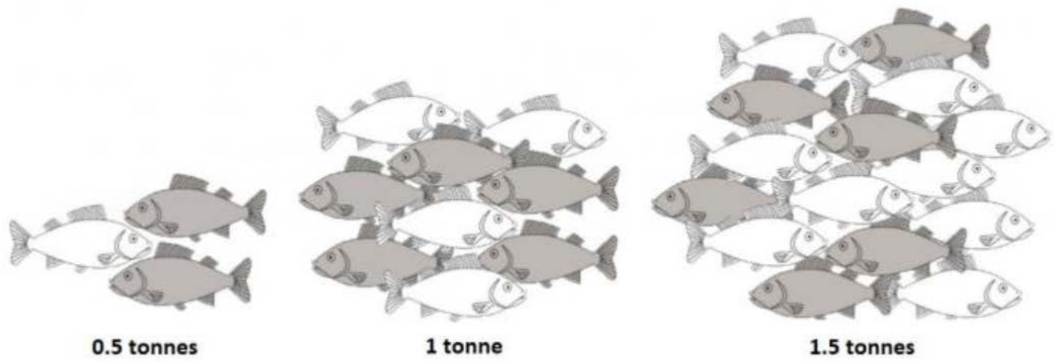


Image: Example of different amounts of fish biomass

In the options, this feature will be displayed as:

Total fish biomass (tonnes)	**0.5** or **1** or **1.5**

FEATURE 2: Attraction of fish to the rigs vs. production of fish on the rigs

The fish biomass that can be found around a rig could consist of either **new fishes produced** because of the new reef or, they are **existing fishes attracted** from nearby places to the rig.

It is thought that if fishes are being **attracted** to the rig, and consequently become concentrated in one place, it would be good for recreational divers and fishers, but could mean they become vulnerable to exploitation.

But, if fishes are being **produced** in the rig, they would be contributing to the total regional fish production.

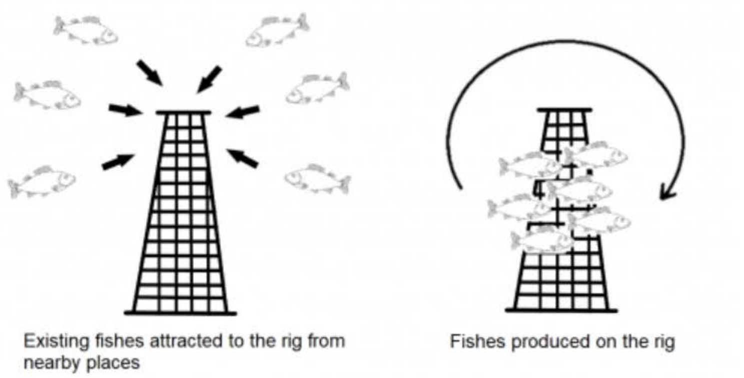


Image: Fish attracted to the rig vs. fish produced on the rig

In the options, this feature will be displayed as:

Fish attracted vs. Fish produced	**Attracted** or **Produced**

FEATURE 3: Habitat for threatened species

Scientists from UWA have found the presence of threatened species in the vicinity of petroleum rigs in WA.

These species are: **Whale Sharks** (endangered), **Round Ribbontail Rays** (vulnerable), and **Giant Manta Rays** (vulnerable).

It is thought that these structures could provide habitat for these species.



Images: Whale Shark; Round Ribbontail Ray; Giant Manta Ray (courtesy of Ningaloo Marine Interactions)

Vulnerable species are ones that have a high risk of extinction in the wild, while endangered species have a very high risk of extinction in the wild, according to IUCN (International Union for Conservation of Nature).

In the options, the new reef may or may not provide habitat for threatened species.
This will be displayed as:

Habitat for threatened species	**Yes** or **No**

FEATURE 4: Who can access the reef

The rig-to-reef could be accessed by **recreational fishers** or **recreational divers,** or it could have **no access** permitted, so it becomes a marine protected area.


Image: Divers on oil rigs (courtesy of Getty Images).

In the options, this feature will be displayed as:

Who can access the reef	**Recreational Fishers** or **Recreational Divers** or **No Access**

FEATURE 5: Future liability in case of any environmental damage ocurring

Liability is defined as the state of being legally responsible for something.

In this case it refers to the **responsibility for any damage or loss** associated with the platform left in the sea.

If an incident occurred, the responsibility (and the associated costs) would fall on either the **Australian Government (the Australian taxpayer)**, the **Oil and Gas Company** that initially owned the rig, or it could be **shared** between both the Government and the Company.

(Image courtesy of freepng.com)

In the options, this feature will be displayed as:

Future liability in case of any environmental damage occurring	**Government (taxpayer)** or **Oil and Gas Company** or **Shared**

FEATURE 6: Amount of money paid to the State budget by the company

If the **company** has to **completely remove** the platform from the sea, it would have to **spend money** in the process (AU$200 million in our hypothetical scenario).

But, if the **company** is allowed to **leave the platform** in the sea (entirely or parts of it) for reefing, it would be **saving money**. This would increase their profits and hence the amount of money that could be paid in taxes.

We assume that, as part of the permission to use the rig for a reef program, **a percentage of this increase in profit** would be paid out to the State budget, which could be used to increase **funding for public health**, **education**, **transport** or **environmental** issues.



(Images courtesy of cleanpng.com)

In the options, we state the **amount of funding** that would come to the State budget, which will be displayed as:

Amount of money (AU$) paid to the State budget by the company	**100 million** or **130 million** or **160 million**

Please, read the following guidelines before proceeding further:

In the following part you will be presented with 6 possible decommissioning scenarios and you will be asked to choose the option that you most prefer.

Each question should be treated independently.

We will be surveying a large number of people to work out the preferences held across the WA community. The findings that emerge from this study may be used to adapt the current policy regarding offshore oil and gas decommissioning in WA.

SAMPLE SCENARIO: below is an example of the type of question you will be presented with (you don't need to answer this one).

When answering the scenarios, don't forget to:

- Consider each option (looking down each column)
- Choose your most preferred option based on the assumption that these are the only options available to you.

Treat each scenario independently. You don't need to remember or anticipate the choices you make across the series of scenarios.

	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	Attracted	
Habitat for threatened species	No	Yes	
Who can access the reef	Recreational Fishers	Recreational Divers	N/A
Future liability in case of any environmental damage occurring	Oil and Gas Company	Government (taxpayer)	
Amount of money (AU$) paid to the State budget by the Company	100 million	160 million	0

N/A: Not Applicable

For example, if you chose option 1, it would mean that you prefer:

- The creation of a rig-to-reef that involves the presence of 0.5 tonnes of fish produced in the rig site, as well as the absence of habitat for threatened species and access for recreational fishers, while the Oil and Gas Company is liable for any possible environmental damage and pays to the State Government AU$100 milion.

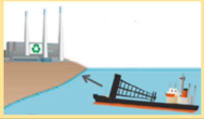
Rather than:

- The creation of a rig-to-reef that involves the presence of 1.5 tonnes of fish attracted to the rig site, as well as habitat for threatened species and access for recreational divers, while the Government (taxpayer) is liable for any possible environmental damage and the Oil and Gas Company pays to the State Government AU$160 million.

- The complete removal of the rig, which involves that there won't be fish biomass produced or attracted to the rig site, and there won't be a potential habitat for threatened species and no access for recreational activities, while there won't be any liability for any possible environmental damage and there won't be extra money paid to the State Government.

SCENARIO 1: Consider the following options. Assuming these are the only options available to you, which one would you choose?

Please, click on the column of your preferred option.

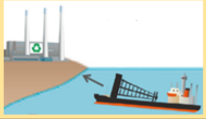
	OPTION 1 **Rig-to-reef** 	**OPTION 2** **Rig-to-reef** 	**OPTION 3** **Complete removal** 
Total fish biomass (tonnes)	0.5	0.5	Negligible
Fish attracted vs. Fish produced	Produced	Produced	
Habitat for threatened species	Yes	Yes	
Who can access the reef	Recreational Divers	Recreational Divers	N/A
Future liability in case of any environmental damage occurring	Oil and Gas Company	Oil and Gas Company	
Amount of money (AU$) paid to the State budget by the Company	100 million	160 million	0

Click on the links below if you want to read the explanations of the features:

- Feature 1 - Total fish biomass
- Feature 2 - Attraction of fish to the rigs vs. production of fish on the rigs
- Feature 3 - Habitat for threatened species
- Feature 4 - Who can access the reef
- Feature 5 - Future liability in case of any environmental damage ocurring
- Feature 6 - Amount of money paid to the state budget by the company

<u>SCENARIO 2</u>: Consider the following options. Assuming these are the only options available to you, which one would you choose?

Please, click on the column of your preferred option.

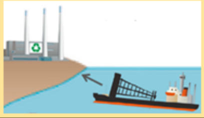
	OPTION 1 **Rig-to-reef** 	**OPTION 2** **Rig-to-reef** 	**OPTION 3** **Complete removal** 
Total fish biomass (tonnes)	1.5	0.5	Negligible
Fish attracted vs. Fish produced	Attracted	Attracted	
Habitat for threatened species	No	Yes	
Who can access the reef	No Access	Recreational Fishers	N/A
Future liability in case of any environmental damage occurring	Shared	Oil and Gas Company	
Amount of money (AU$) paid to the State budget by the Company	130 million	130 million	0

Click on the links below if you want to read the explanations of the features:

- Feature 1 - Total fish biomass
- Feature 2 - Attraction of fish to the rigs vs. production of fish on the rigs
- Feature 3 - Habitat for threatened species
- Feature 4 - Who can access the reef
- Feature 5 - Future liability in case of any environmental damage ocurring
- Feature 6 - Amount of money paid to the state budget by the company

SCENARIO 3: Consider the following options. Assuming these are the only options available to you, which one would you choose?

Please, click on the column of your preferred option.

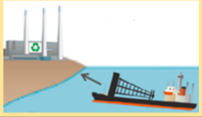
	OPTION 1 Rig-to-reef 	OPTION 2 Rig-to-reef 	OPTION 3 Complete removal 
Total fish biomass (tonnes)	1.5	1	Negligible
Fish attracted vs. Fish produced	Attracted	Produced	
Habitat for threatened species	No	No	
Who can access the reef	Recreational Fishers	No Access	N/A
Future liability in case of any environmental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

Click on the links below if you want to read the explanations of the features:

- Feature 1 - Total fish biomass
- Feature 2 - Attraction of fish to the rigs vs. production of fish on the rigs
- Feature 3 - Habitat for threatened species
- Feature 4 - Who can access the reef
- Feature 5 - Future liability in case of any environmental damage ocurring
- Feature 6 - Amount of money paid to the state budget by the company

SCENARIO 4: Consider the following options. Assuming these are the only options available to you, which one would you choose?

Please, click on the column of your preferred option.

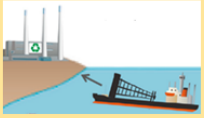
<table>
<tr><th></th><th>OPTION 1
Rig-to-reef
</th><th>OPTION 2
Rig-to-reef
</th><th>OPTION 3
Complete removal
</th></tr>
<tr><td>Total fish biomass (tonnes)</td><td>1.5</td><td>1</td><td>Negligible</td></tr>
<tr><td>Fish attracted vs. Fish produced</td><td>Attracted</td><td>Produced</td><td rowspan="4">N/A</td></tr>
<tr><td>Habitat for threatened species</td><td>Yes</td><td>No</td></tr>
<tr><td>Who can access the reef</td><td>Recreational Fishers</td><td>Recreational Divers</td></tr>
<tr><td>Future liability in case of any environmental damage occurring</td><td>Government (taxpayer)</td><td>Shared</td></tr>
<tr><td>Amount of money (AU$) paid to the State budget by the Company</td><td>160 million</td><td>100 million</td><td>0</td></tr>
</table>

Click on the links below if you want to read the explanations of the features:

- Feature 1 - Total fish biomass
- Feature 2 - Attraction of fish to the rigs vs. production of fish on the rigs
- Feature 3 - Habitat for threatened species
- Feature 4 - Who can access the reef
- Feature 5 - Future liability in case of any environmental damage ocurring
- Feature 6 - Amount of money paid to the state budget by the company

SCENARIO 5: Consider the following options. Assuming these are the only options available to you, which one would you choose?

Please, click on the column of your preferred option.

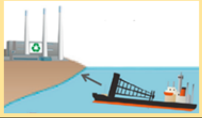
	OPTION 1 **Rig-to-reef** 	**OPTION 2** **Rig-to-reef** 	**OPTION 3** **Complete removal** 
Total fish biomass (tonnes)	0.5	1	Negligible
Fish attracted vs. Fish produced	Attracted	Attracted	N/A
Habitat for threatened species	Yes	No	
Who can access the reef	Recreational Fishers	No Access	
Future liability in case of any environmental damage occurring	Oil and Gas Company	Oil and Gas Company	
Amount of money (AU$) paid to the State budget by the Company	130 million	130 million	0

Click on the links below if you want to read the explanations of the features:

- Feature 1 - Total fish biomass
- Feature 2 - Attraction of fish to the rigs vs. production of fish on the rigs
- Feature 3 - Habitat for threatened species
- Feature 4 - Who can access the reef
- Feature 5 - Future liability in case of any environmental damage ocurring
- Feature 6 - Amount of money paid to the state budget by the company

SCENARIO 6: Consider the following options. Assuming these are the only options available to you, which one would you choose?

Please, click on the column of your preferred option.

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

If the respondent always chose the Status Quo:

You always preferred the ‘Complete Removal’ option over 'Rigs-to-Reefs'. Please provide your reason why:

- I object to the idea of leaving oil rigs in the sea. I think they contribute to ocean pollution
- I need to know more about decommissioning options before I would feel comfortable deciding on which option is suitable
- I don’t trust governments to implement and regulate decommissioned oil rigs
- I found the choices difficult or confusing, so I preferred the ‘Complete Removal’ option
- Other:

Please, indicate how certain you were of the answers you gave in the different scenarios, from "Not certain at all" (1) to "Very certain" (7)

	Not at all certain						Very certain
	1	2	3	4	5	6	7
How certain were you of the answers you gave in the different scenarios?							

Did you think that the scenarios were confusing?

- ○ Yes
- ○ No

What did you think about the information that was provided to describe the decommissioning options?

- ○ It was confusing
- ○ I thought the description was insufficient
- ○ I thought it was an informative and sufficient information

Which features used to describe the decommissioning options were relevant to you?

- ☐ Habitat for endangered species
- ☐ Total fish biomass
- ☐ Fish attracted vs. fish produced
- ☐ Who can access the reef
- ☐ Future liability
- ☐ Amount of money paid to the State budget by the company
- ☐ None

If the respondent answered "None":

In your opinion, which other features should have been included to describe the decommissioning options?

Please, indicate on the following scale how likely you think it is that the results of this study will influence future policy decisions regarding offshore oil and gas decommissioning in Western Australia from "Not at all likely" (1) to "Very likely" (7)

Not at all likely — Very likely

1 2 3 4 5 6 7

How likely do you think it is that the results of this study will influence future policy decisions?

PART 4: In this section of the survey, we will ask some questions about you.
The information collected will be kept anonymous.

Do you have any children?

- Yes-dependent
- Yes-independent
- No

What is the highest level of education you have achieved?

- Primary
- Secondary
- TAFE or other college
- University undergraduate
- University postgraduate

Which of the following household incomes before tax applies to you?

- Under $20.000
- $20.000 - $35.000
- $35.000 - $50.000
- $50.000 - $70.000
- $70.000 - $100.000
- $100.000 - $130.000
- Over $150.000
- I would rather not say

What is your residential postcode?

Thank you very much for your time!
If you have comments you want to make about the survey, or the issues raised in it, please add them below:

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

Appendix 8 Combined workshop feedback report

Fran Ackermann & Georgina Hill

This appendix is part of the final report for:

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

Euan S. Harvey, Fran Ackermann, Michael Burton, Julian Clifton, Carmen Elrick-Barr, Johanna Zimmerhackel, Georgina Hill, Stephen J Newman, Jenny Shaw, Mark Pagano, Paul Mcleod, Dianne McLean, Julian Partridge

24th August 2021

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

Exmouth Workshops Feedback Report

FRDC
FISHERIES RESEARCH & DEVELOPMENT CORPORATION

Curtin University

THE UNIVERSITY OF WESTERN AUSTRALIA

WESTERN AUSTRALIAN MARINE SCIENCE INSTITUTION

Table of Contents

Executive Summary

As part of the research project focusing on “Enhancing the Understanding of the Value Provided to Fisheries by Man-Made Aquatic Structures” two workshops were conducted in Exmouth in October 2019. These workshop focused on exploring the issues and opportunities regarding man-made marine infrastructure (MMI) along with determining social values associated with a prioritised subset of themes. The two workshops, both facilitated by Fran Ackermann, involved 15 members of the Exmouth community and used a computer – based system to capture, model and synthesise views. The report focuses purely on the material generated from the two workshops and will be augmented with further workshops in Onslow, Karratha and Busselton, the results of a survey and various economic value assessment analyses.

This short report comprises of:

1. Project Background
2. A brief overview of the method underpinning the workshops and outcomes
3. An overview map detailing the social values relating to MMI for both workshops
4. A list of project next steps regarding social value

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number CTR-10729).

Project Background

This project is a collaboration between the Fisheries Research and Development Corporation, Curtin University, The University of Western Australia and the West Australian Marine Science Institute to explore the socioeconomic values associated with MMI. The project has four aims:

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 manmade aquatic structures in the marine environment.
2. To collate a list and description of the manmade 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 manmade 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 manmade 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.

Initial findings from a literature review exploring social and economic values associated with MMI demonstrated that gaps exist within the current body of available research. These include: being discrete in nature, limited diversity of stakeholder view (e.g. focused on one or two groups only), limited specific exploration of MMI (e.g. natural reefs rather than artificial), and not being specifically applicable to a West Australian context (e.g. primarily from other states or countries). As such, using only existing literature to inform this research project would be insufficient.

In order to achieve our research aims the team are undertaking further data collection to including holding workshops using decision support systems in Exmouth, Karratha, Onslow, Dunsborough, and Busselton, creating and disseminating a survey for recreational fishers and divers, and determining the monetary value MMI generated by the structures and associated activities Throughout the data collection process integration between social and economic findings will be completed to achieve a broad and well-informed picture of qualitative, semi-quantitative and quantitative aspects associated with MMI.

Brief Overview

Exmouth Workshops, the Ningaloo Centre Bundegi Boardroom

15th of October 2019

- Participant 1
- Participant 2
- Participant 3
- Participant 4
- Participant 5
- Participant 6
- Participant 7

16th of October 2019

- Participant 1
- Participant 2
- Participant 3
- Participant 4
- Participant 5
- Participant 6
- Participant 7
- Participant 8

Facilitator: Fran Ackermann

Overview

The workshops focused on "what are the issues and opportunities regarding man-made marine infrastructure?" Participants were asked to consider this from the perspective of 'you as part of your community' rather than representing their organisation. Using a group mapping process, each individual was able to anonymously contribute to the focal question, seeing their ideas appear on a public screen as well as their own laptop. Members were then able to 'piggy back' off one another providing a rich reservoir of contributions (see appendix for a photograph of the group using the system).

These contributions were clustered by the facilitator according to content and then reviewed by the group to ensure coherence. New material that emerged from the review discussion was captured. This was both in the form of statements and also relationships. As a systemic understanding was sought (for greater robustness) where one contribution impacted another – causal relationships in the form of arrows were captured. This combination of ideas and associations helped in building a shared and detailed understanding of the considerations regarding key issues and opportunities. The process thus helped tease out a rich picture of the components and their systemic properties reflecting the complexity of the topic. In Workshop One, 28 contributions were collected and clustered into 10 themes. Workshop Two produced 52 contributions which were clustered 13 themes. Initial themes can be viewed in Table 1.

Following the initial capture and structuring of the material into themes a prioritisation exercise was undertaken. The prioritisation process first asked participants to determine which of the themes they believed were 'important to you personally' (blue preferences) and which were 'important to the community' (green preferences). Statements could be allocated both green and blue preferences. The results from these activities were appended to the statements e.g. [2B 4G] B=Blue and G=Green (see Table 1).

Workshop One prioritised the theme of "*increased habitat*" as most important to individuals and the theme of "*careful consideration of location*" of MMI as most important to the community. Workshop Two viewed themes "*increased impact (on land/marine) of more people in an area that they were not visiting previously*" and "*opportunity to test novel techniques for building resilience in marine communities in face of climate change*" as equally important to the individual. Additionally, "*increased visitation to the area which would need to be carefully managed and planned for*" and "*increased tourism industry opportunities*" were prioritised as equal first for most important to the community.

Table 1. Identified themes and their prioritisations to the individual and the community.

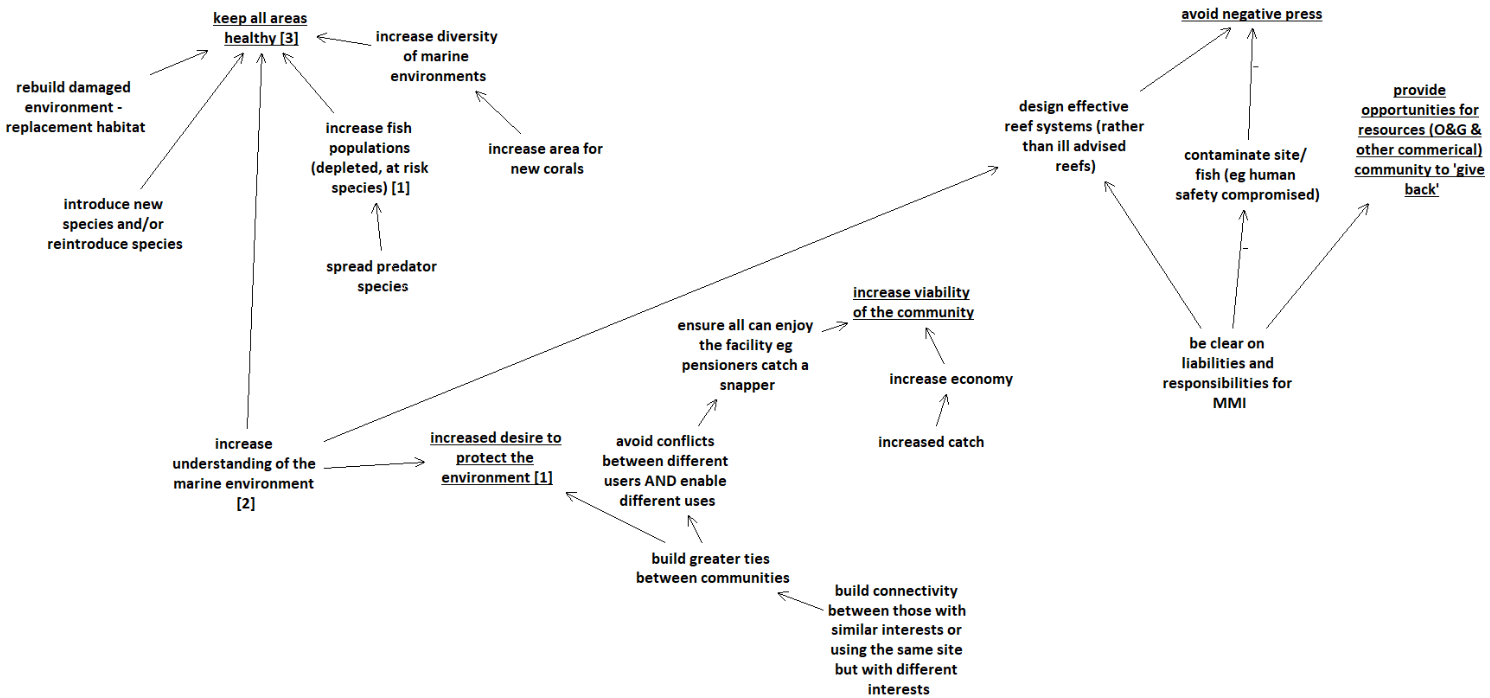
Workshop One	Workshop Two
• Careful consideration of location [3B 6G] • Increased habitat [8B 5G] • Spread of pressure on reef systems [4B 4G] • Increase awareness and appreciation of what is in the marine environment [3B 2G] • Recognise competing interest [1B 3G] • Responsibility for long term maintenance [1B 2G] • Able to gain evidence of benefits of artificial reefs [4B 1G] • Detrimental impacts to adjacent areas and species [2B 1G] • Job/employment opportunities [1B 3G] • Potential for pollution ([1B 1G]	• Increased visitation to the area which would need to be carefully managed and planned for [4B 8G] • Increased tourism industry opportunities [3B 8G] • Ensure community engaged & involved in process of MMI [5B 7G] • Increased impact (on land/marine) of more people in an area that they were not visiting previously [6B 5G] • Potential pollution of marine environment from poorly thought out or maintained infrastructure [5B 4G] • Provide education to users (and potential users) [5B 4G] • Opportunity to test novel techniques for building resilience in marine communities in face of climate change [6B 2G] • Rehabilitation of /creation of new coral reef systems [4B 3G] • Provide for an increase in fish stocks [5B 3G] • Provide infrastructure for marine use [2B 2G] • Negatively change the natural environment [4B 2G] • Can create hazards (human safety and marine life) if not planed out correctly [4B 1G] • Uncertainty around ongoing burden of responsibility of any maintenance and safety around artificial structures [3B 6G]

After a coffee break activities focused on developing the value system. In Workshop One, each individual theme was focused on to tease out associated social values. This was due to the more discrete nature of the themes. In Workshop Two, a more systemic view was taken and social values were teased out in relation to all identified themes. Maps detailing all social values extracted from each workshop can be viewed below. It was interesting to note that whilst there was a high degree of homogeneity there were also some significant differences between the two value systems. To conclude the workshops, each participant voted anonymously on which social value they personally cared about most. Workshop One's key social value was determined as "keep all areas healthy" while Workshop Two's was "protect the natural environment".

In summary, each workshop provided a good understanding of the issues and opportunities – in terms of themes and their interconnections – giving a rich appreciation of considerations to be borne in mind whenever contemplating the use of MMI. The workshops also gave rise to 2 value systems providing not only a far more nuanced understanding of the wealth of values to be considered (beyond much of what is already asserted) but a systemic understanding of the values – reflecting the complexity of the topic. The workshops allowed the views of those from a range of different backgrounds/knowledge bases and organisational stances to contribute enabling both a deeper understanding for the researchers as well as those attending. As a general observation it was clear that the Exmouth community involved in the workshops care deeply about the protection and sustainability of the marine environment

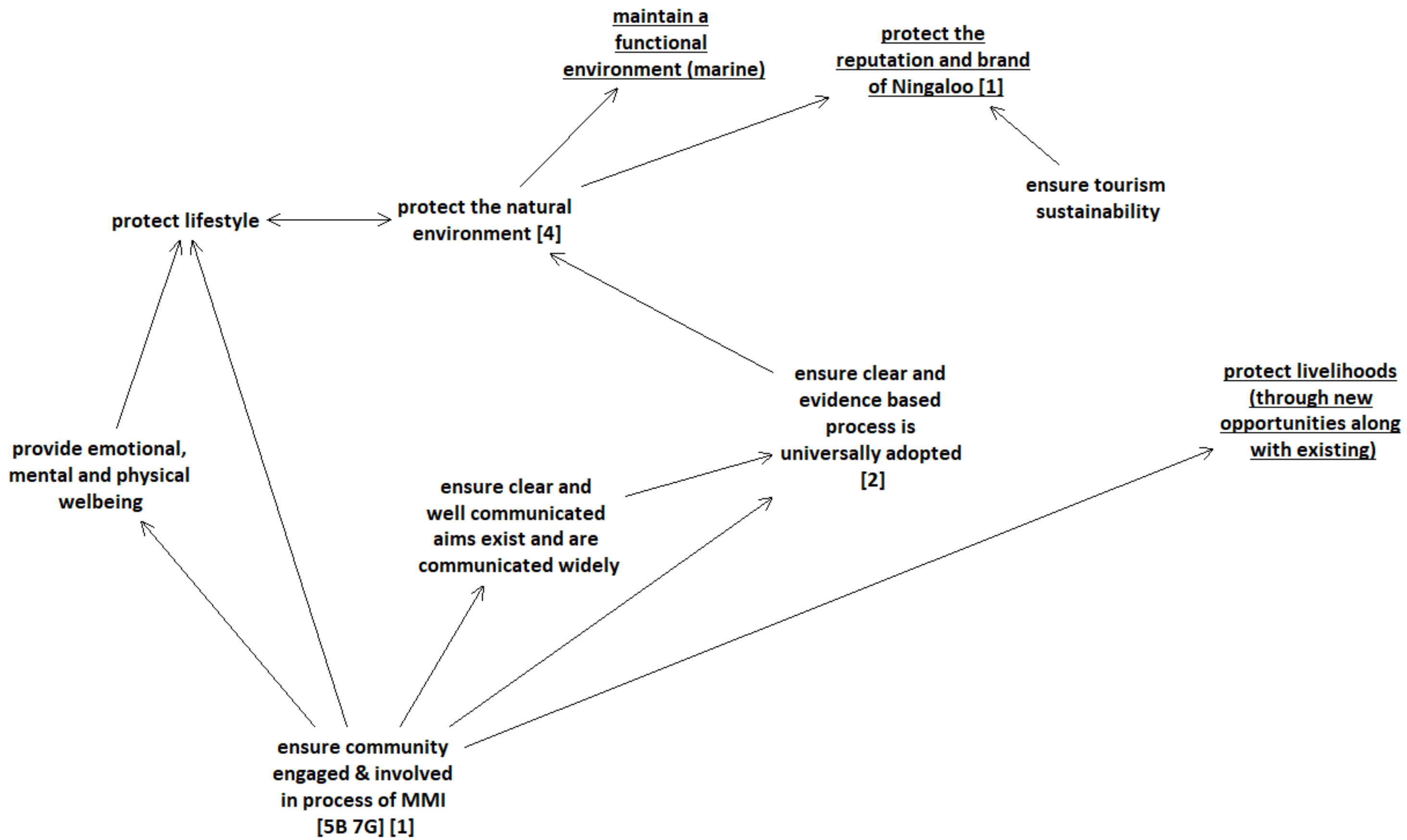
This material will be augmented with that captured from further workshops, the survey and other analyses to provide decision makers and interested parties with a detailed understanding of the social and economic values associated with man-made marine infrastructure.

Figure 1. Workshop One Social Value Associated with MMI Diagram



Note: Numbers displayed in brackets '[1]' represent how many participants voted that social value or goal as 'most important' to them. Arrows are read as 'may lead to' i.e. increase understanding of the marine environment may lead to keep all areas healthy. A minus sign on the arrow head reflects the opposite i.e. contaminate site/fish may lead to [not] avoid negative press

Figure 2. Workshop Two Social Value Associated with MMI Diagram



Note: Numbers displayed in brackets '[1]' represent how many participants voted that social value or goal as 'most important' to them.

A double headed arrow between protect lifestyle and protect the natural environment illustrates the self-sustaining nature of the relationship.

Next Steps

1. Conduct further 'workshops' with multiple stakeholder groups in Onslow, Karratha, and Busselton
2. Integrate, compare and contrast findings from all workshops along with material from a workshop undertaken with the steering committee
3. Develop a causal model depicting social values and man-made aquatic infrastructure within the West Australia context
4. Develop semi quantitative models including Multi-Criteria Decision Models to further assess and understand social value
5. Integrate workshop findings with findings from other parts of the research project (literature review, survey data, economic data etc.)

Appendix

Exmouth workshop participants and facilitator pictured with group mapping system

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

Chevron Workshop Feedback Report

Table of Contents

Executive Summary

As part of the research project focusing on “Enhancing the Understanding of the Value Provided to Fisheries by Man-Made Aquatic Structures” an online workshop was conducted on the 23rd of April 2020. This workshop focused on exploring the issues and opportunities regarding man-made marine structures (MMS) along with determining social values associated with a prioritised subset of themes. The workshop, facilitated by Fran Ackermann, involved 3 members of Chevron and 1 member WAMSI and used an online computer – based system to capture, model and synthesise views. The report focuses purely on the material generated from the workshop and will be augmented with further online workshops, the results of a survey and various economic value assessment analyses.

This short report comprises of:

1. Project Background
2. A brief overview of the method underpinning the workshops and outcomes
3. An overview map detailing the, opportunities, issues and social values relating to MMS for both workshops
4. A list of project next steps regarding social value

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number CTR-10729).

Project Background

This project is a collaboration between the Fisheries Research and Development Corporation, Curtin University, The University of Western Australia and the West Australian Marine Science Institute to explore the socioeconomic values associated with MMS. The project has four aims:

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 manmade aquatic structures in the marine environment.
2. To collate a list and description of the manmade 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 manmade 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 manmade 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.

Initial findings from a literature review exploring social and economic values associated with MMS demonstrated that gaps exist within the current body of available research. These include: being discrete in nature, limited diversity of stakeholder view (e.g. focused on one or two groups only), limited specific exploration of MMS (e.g. natural reefs rather than artificial), and not being specifically applicable to a West Australian context (e.g. primarily from other states or countries). As such, using only existing literature to inform this research project would be insufficient.

In order to achieve our research aims the team are undertaking further data collection to including holding online workshops using decision support systems with people from Perth, Exmouth, Karratha, Onslow, Dunsborough, and Busselton, creating and disseminating a survey for recreational fishers and divers, and determining the monetary value MMS generated by the structures and associated activities. Throughout the data collection process integration between social and economic findings will be completed to achieve a broad and well-informed picture of qualitative, semi-quantitative and quantitative aspects associated with MMS.

Brief Overview

Online Chevron Workshop, 23rd of April 2020

- Participant 1
- Participant 2
- Participant 3
- Participant 4

Facilitator: Fran Ackermann, Euan Harvey

Overview

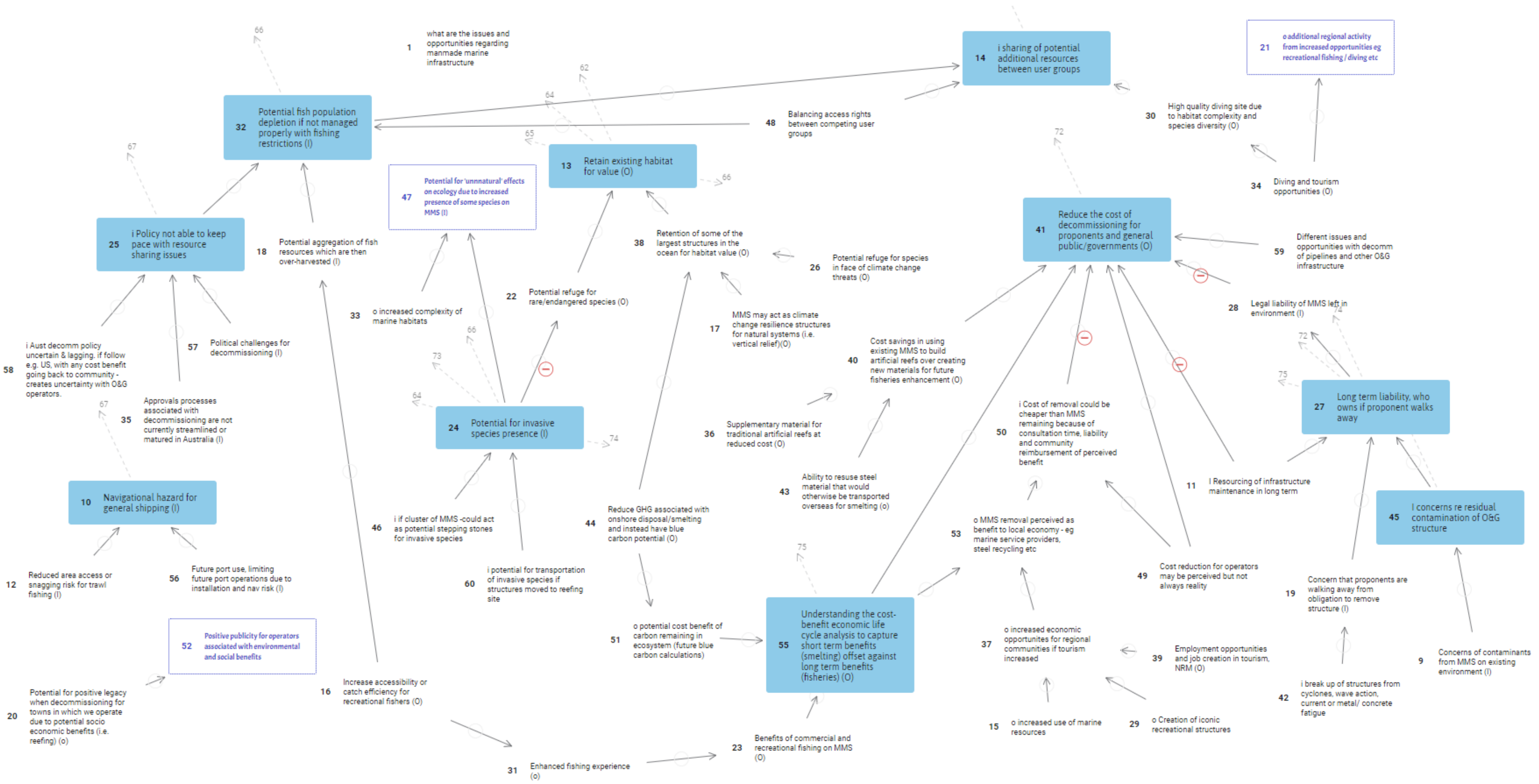
The workshops focused on “what are the issues and opportunities regarding man-made marine infrastructure?” Each participant was given the opportunity to contribution both Issues and Opportunities (denoted by ‘I’ or ‘O’) in relation to the focal question. Using a group mapping process, each participant could anonymously contribute to the focal question, seeing their ideas and the contributions of others on their screen and thus ‘piggy back’ off one another providing a rich reservoir of contributions. This process generated 51 statements. There were 26 Opportunities and 25 Issues reflecting an *even balance*. The surfaced material was put into rough ‘content oriented’ clusters and subsequently reviewed by the group allowing for new material to be surfaced as well as to ensure all were clear as to the meaning of the statements.

During the process of elaboration, it became clear that a number of the statements impacted others and so the process of causally linking the statements together was undertaken. This resulted in a ‘map’ of interconnected issues and opportunities helping tease out a rich picture of the statements along with their systemic properties reflecting the complexity of the topic The linked clusters were reviewed and ‘headline’ statements (10 in total) identified and given a different style (blue box). Each represented a specific theme. Map 1 shows the issues, opportunities and headline statements.

To conclude the first part of the morning session, a prioritisation process was undertaken asking the participants to rate the headline statements (see Appendix 1).

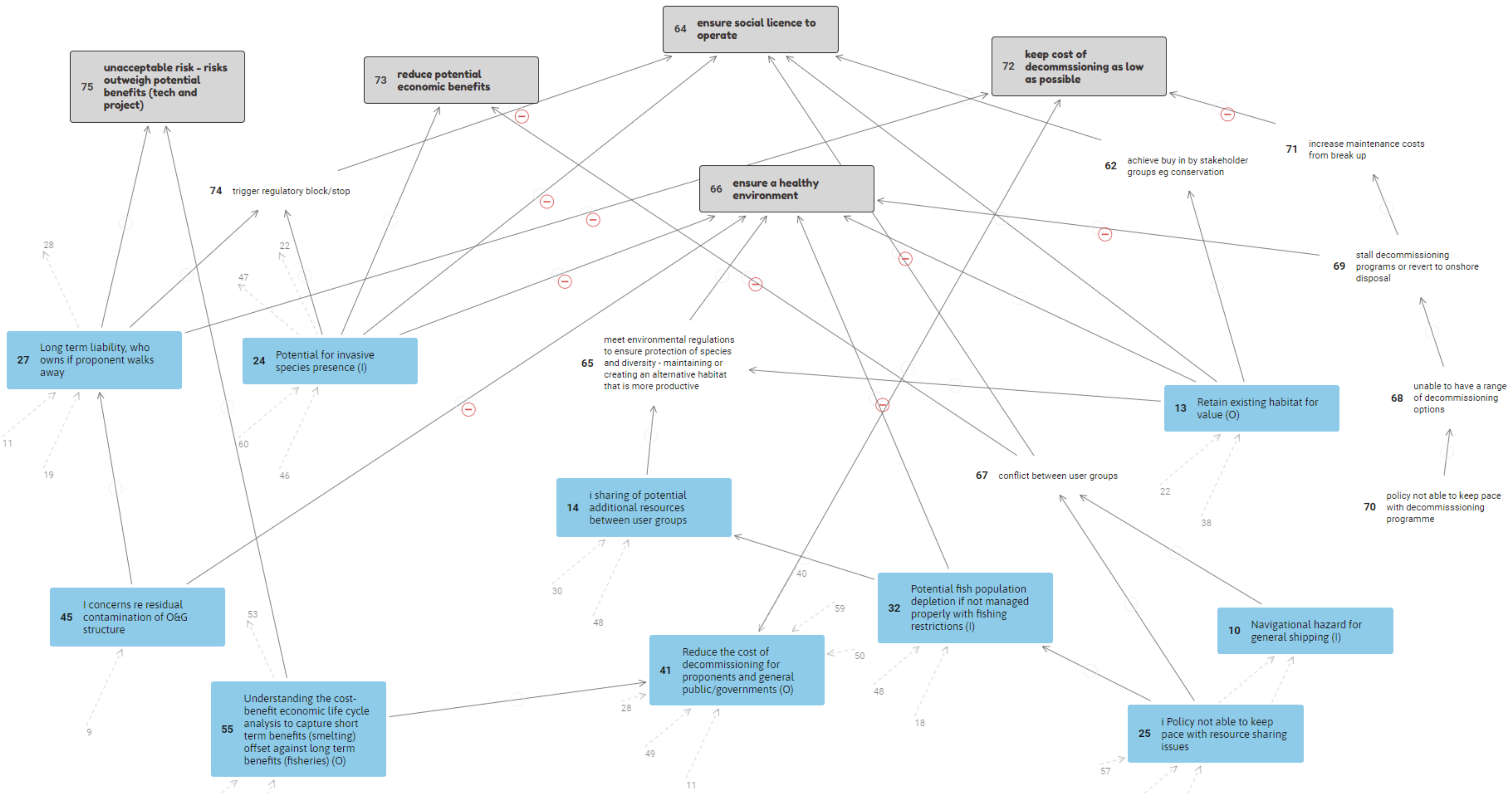
Results. After a brief break, the group reviewed the headline issues and explored the implications of each, i.e. what value they either supported (opportunities) or attacked (issues). A resulting set of 5 values was identified (grey box). Map 2 showings the headline issues, values and interconnecting material.

Map 1. Issues and opportunities identified in the workshop



Note: 'Blue boxes' refer to headline statements. A minus sign on the arrowhead reflects a negative link

Map 2. Social values identified in the online workshop



Note: 'Grey boxes' refer to social values. A minus sign on the arrowhead reflects the opposite.

Next Steps

1. Conduct further 'workshops' with multiple stakeholder groups for example regulators, commercial fishing, Onslow, Karratha, and Busselton
2. Integrate, compare and contrast findings from all workshops along with material from a workshop undertaken with the steering committee and 2 undertaken with Exmouth participants
3. Develop a causal model depicting social values and man-made aquatic infrastructure within the West Australia context
4. Develop semi quantitative models including Multi-Criteria Decision Models to further assess and understand social value
5. Integrate workshop findings with findings from other parts of the research project (literature review, survey data, economic data etc.)

Appendix 1

Rating of importance of issues and opportunities as a Chevron employee

Headline Statement	Average Rating (out of 10)	Degree of Consensus
Long term liability – who owns if proponent walks away (I)	9.0	0.71
Reduce the cost of decommissioning for proponents and general public government (O)	8.30	1.90
Understanding the cost-benefit economic life cycle analysis to capture short term benefits (smelting) offset against long term benefits (fisheries) (O)	6.50	2.50
Policy not able to keep pace with resource sharing issues (I)	6.30	1.50
Retain existing habitat for value (O)	5.80	2.50
Concerns re residual contamination of O&G structure (I)	5.50	1.80
Navigational hazard for general shipping (I)	4.30	2.80
Sharing of potential resources between user groups (I)	3.50	3.30
Potential for invasive species presence (I)	3.30	1.80
Potential fish populations not managed properly with fishing restrictions (I)	3.0	0.71

Note that liability emerged as not only being the most important but also with the highest degree of consensus. Second was reducing the cost of decommissioning but with less consensus.

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

Online Oil and Gas Workshop Feedback Report

Table of Contents

Executive Summary

As part of the research project focusing on "Enhancing the Understanding of the Value Provided to Fisheries by Man-Made Aquatic Structures" two online workshops were conducted. The first was on the 23rd of April 2020 and the second on the 21st May 2020. These workshops focused on exploring the issues and opportunities regarding man-made marine structures (MMS) along with determining social values associated with a prioritised subset of themes. The workshops, facilitated by Fran Ackermann and supported by Euan Harvey and Georgie Hill, involved a number of participants and used an online computer – based system to capture, model and synthesise views. This report focuses purely on the material generated from the workshops, however, this material will be integrated with material from other online workshops and those conducted face to face, as well as with the results of a survey and various economic value assessment analyses.

This short report comprises of:

5. Project Background
6. A brief overview of the method underpinning the workshops and outcomes
7. An overview map detailing the, opportunities, issues and social values relating to MMS for both workshops
8. A list of project next steps regarding social value

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number CTR-10729).

Project Background

This project is a collaboration between the Fisheries Research and Development Corporation, Curtin University, The University of Western Australia and the West Australian Marine Science Institution to explore the socioeconomic values associated with MMS. The project has four aims:

5. 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.
6. 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.
7. 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.
8. 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.

Initial findings from a literature review exploring social and economic values associated with MMS demonstrated that gaps exist within the current body of available research. These include: being discrete in nature, limited diversity of stakeholder view (e.g. focused on one or two groups only), limited specific exploration of MMS (e.g. natural reefs rather than artificial), and not being specifically applicable to a West Australian context (e.g. primarily from other states or countries). As such, using only existing literature to inform this research project would be insufficient.

In order to achieve our research aims the team are undertaking further data collection to including holding online workshops using decision support systems with people from Perth, Exmouth, Karratha, Onslow, Dunsborough, and Busselton, creating and disseminating a survey for recreational fishers and divers, and determining the monetary value MMS generated by the structures and associated activities. Throughout the data collection process integration between social and economic findings will be completed to achieve a broad and well-informed picture of qualitative, semi-quantitative and quantitative aspects associated with MMS.

Brief Overview

Online Oil and Gas Workshop, 21st of May 2020

- Participant 1
- Participant 2
- Participant 3
- Participant 4
- Participant 5

Online Chevron Workshop, 23rd of April 2020

- Participant 1
- Participant 2
- Participant 3
- Participant 4

Facilitators: Fran Ackermann, Euan Harvey, Georgie Hill

Overview

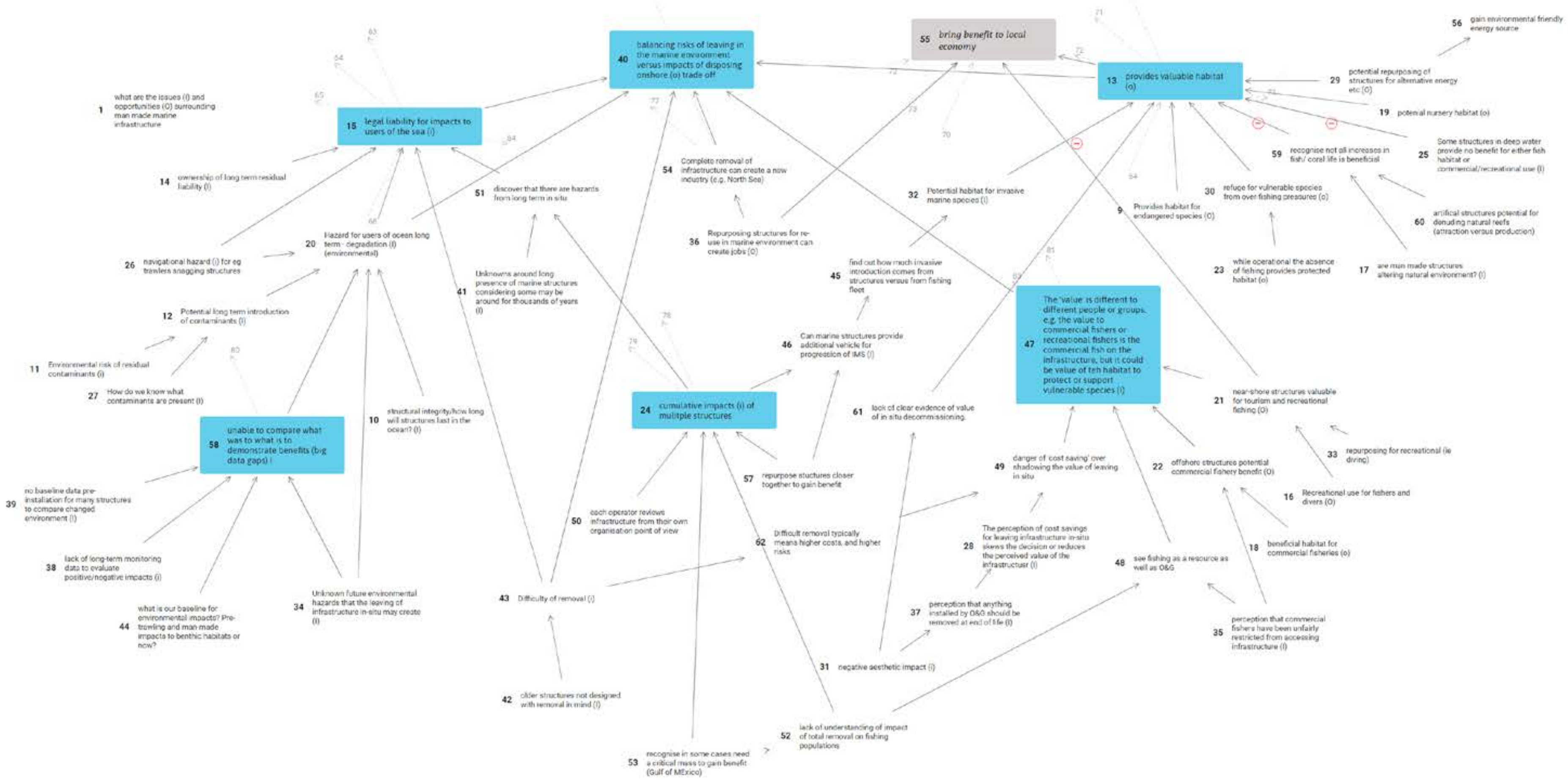
The workshops focused on "what are the issues and opportunities regarding man-made marine infrastructure?" Each participant was given the opportunity to contribution both Issues and Opportunities (denoted by 'I' or 'O') in relation to the focal question. Using a group mapping process, each participant could anonymously contribute to the focal question, seeing their ideas and the contributions of others on their screen and thus 'piggyback' off one another providing a rich reservoir of contributions. The surfaced material was put into rough 'content oriented' clusters and subsequently reviewed by the group allowing for new material to be surfaced as well as to ensure all were clear as to the meaning of the statements.

During the process of elaboration, it became clear that a number of the statements impacted others and so the process of causally linking the statements together was undertaken. This resulted in a 'map' of interconnected issues and opportunities helping tease out a rich picture of the statements along with their systemic properties reflecting the complexity of the topic The linked clusters were reviewed and 'headline' statements identified and given a different style (blue box). Each represented a specific theme. Map 1 shows the issues, opportunities and headline statements for the Oil and Gas workshop and Map 2 shows the same for the Chevron workshop.

To conclude the first part of the morning session, a prioritisation process was undertaken asking the participants to rate the headline statements (see Table 3 for Oil and Gas and table 6 for Chevron).

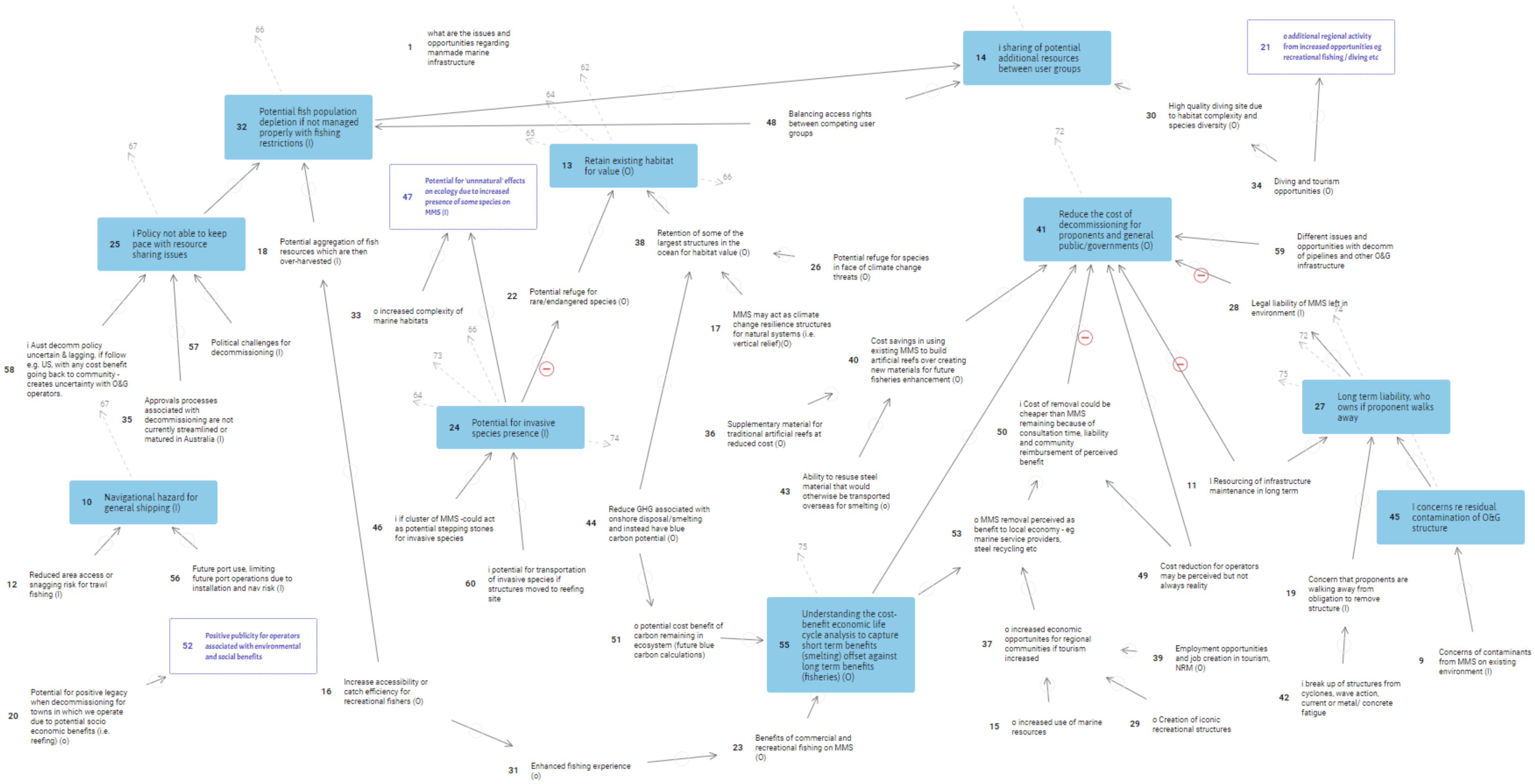
Results. After a brief break, the group reviewed the headline issues and explored the implications of each, i.e. what value they either supported (opportunities) or attacked (issues). Each value was identified and given a particular attribute (grey box). Map 3 showings the headline issues, values and interconnecting material for Oil and Gas and Map 4 shows this for Chevron.

Map 1. Issues and opportunities identified in the oil and gas workshop



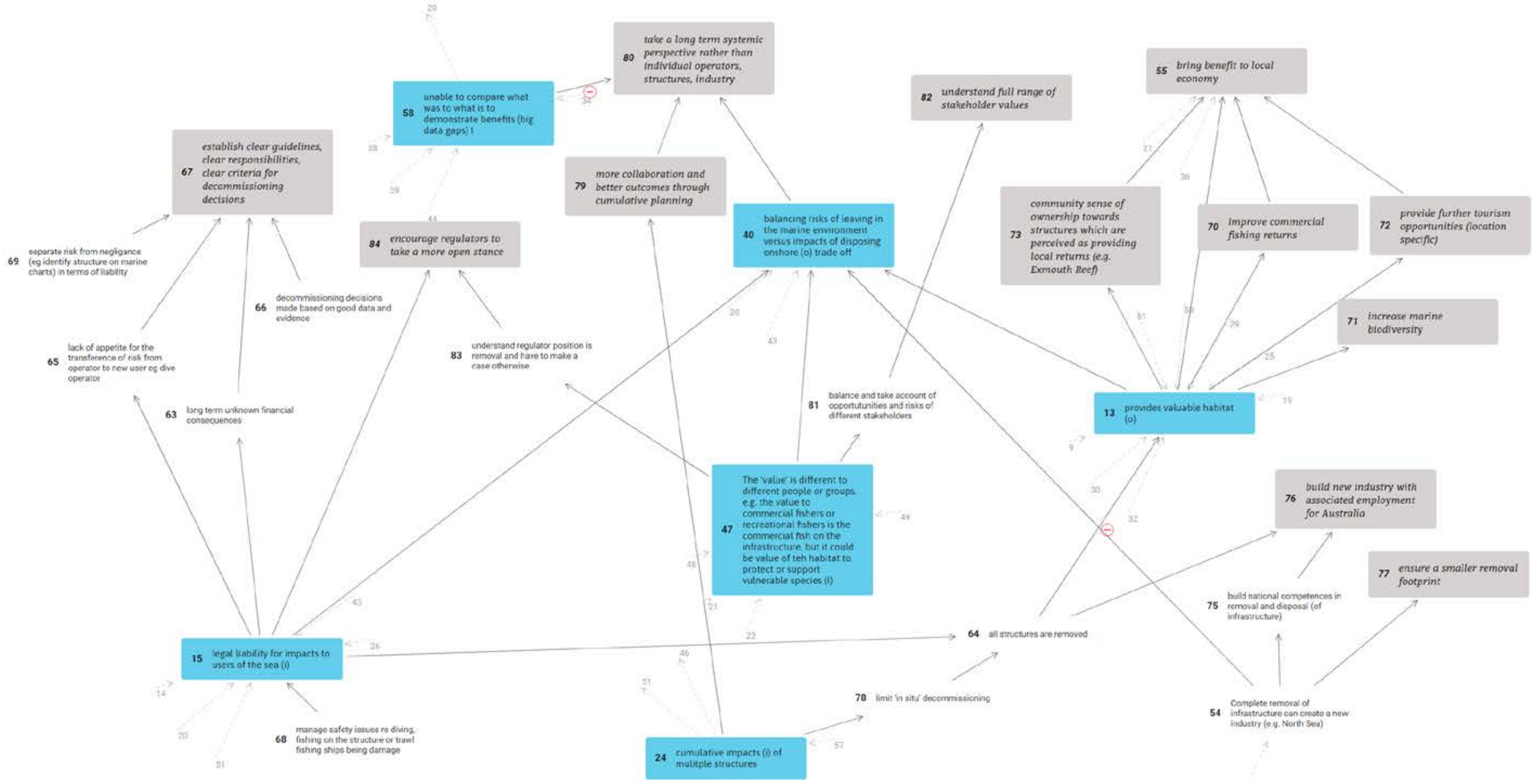
Note: ‘Blue boxes’ refer to headline statements. A minus sign on the arrowhead reflects a negative link

Map 2. Issues and opportunities identified in the Chevron workshop



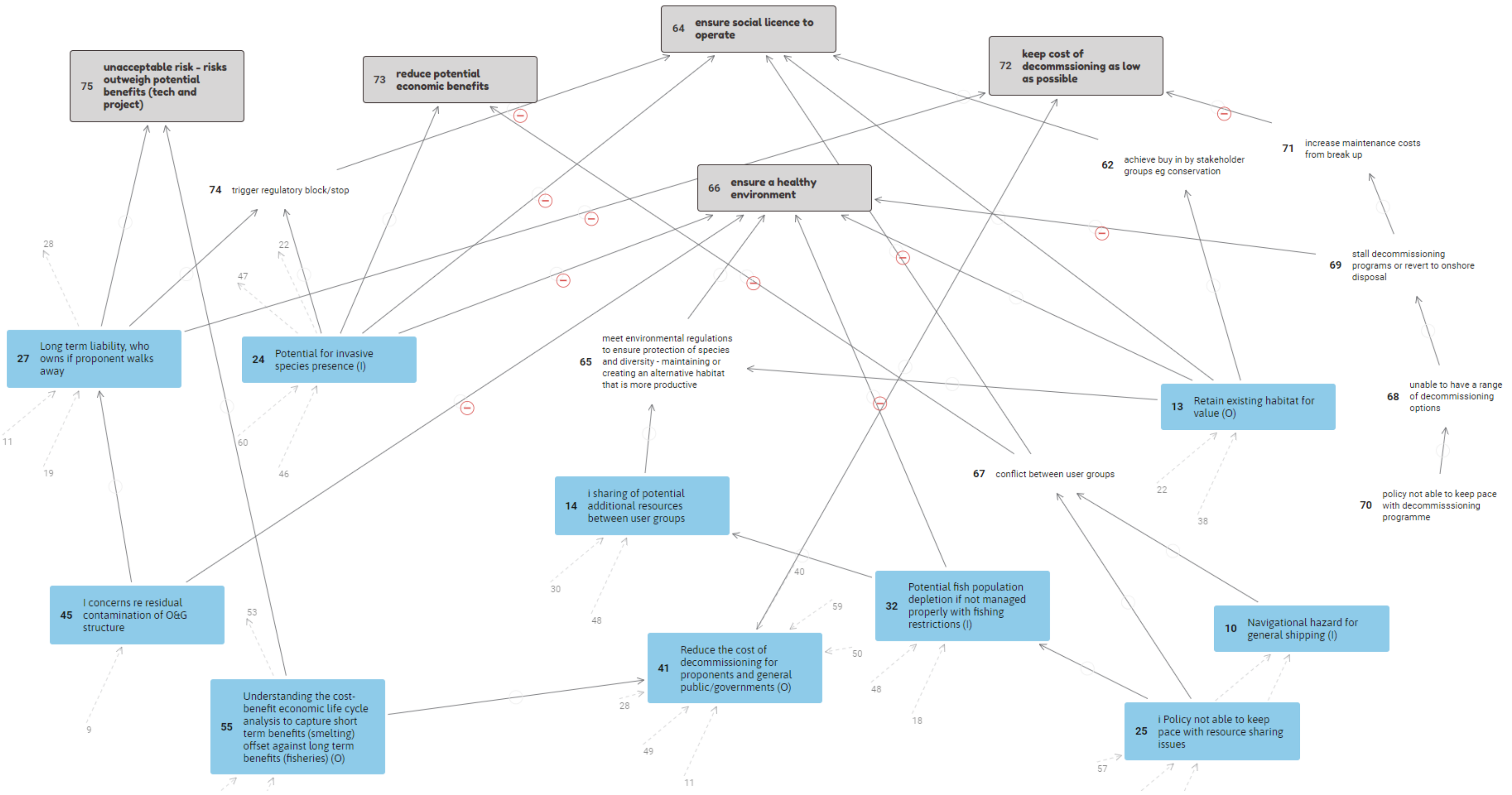
Note: 'Blue boxes' refer to headline statements. A minus sign on the arrowhead reflects a negative link

Map 3. Social values identified in the oil and gas workshop



Note: 'Grey boxes' refer to social values. A minus sign on the arrowhead reflects the opposite.

Map 4. Social values identified in the Chevron workshop



Note: 'Grey boxes' refer to social values. A minus sign on the arrowhead reflects the opposite.

Reflections from the Oil and Gas Workshop

Reviewing the Issues and Opportunities

- Number of issues = 36, number of opportunities = 18 – revealing that participants believed there were more potential issues than opportunities.

Table 1. Themes (headlines) and supporting issues and opportunities (identified through links)

Theme	Issues and Opportunities
58. Unable to compare what was to what is to demonstrate benefits (big data gaps) (I)	39 (I), 38 (I), 44 (I), 34 (I),
24. Cumulative impacts of multiple structures (I)	50 (I), 53 (I), 52 (I), 57 (O)
47. The 'value' is different to different people or groups e.g. the value to commercial fishers or recreational fishers is the commercial fish on the infrastructure but it could be value of the habitat to protect or support vulnerable species (I)	49 (I), 62 (I), 28 (I), 48 (O), 22 (O), 35 (I), 18 (O), 21 (O), 16 (O), 33 (O), 52 (I), 43 (O)
13. Provides valuable habitat (O)	32 (I), 45 (O), 9 (O), 30 (O), 23 (O), 59 (I), 17 (I), 60 (I), 25 (I), 19 (O), 29 (O)
15. Legal liability for impacts to users of the sea (I)	14 (I), 26 (I), 20 (I), 43 (I), 68 (I), 51 (I), 10 (I), 34 (I), 12 (I), 41 (I),
40. Balancing risks of leaving in the marine environment versus impact of disposing onshore tradeoffs (O)	20 (I), 54 (O), 43 (I), 36 (O),

- The themes are not mutually exclusive – they share statements – representing the systemic nature.
- In some instances themes comprise both Issues and Opportunities demonstrating potential dilemmas. The theme concentrating on 'Provide Valuable Habitat' is one such theme
- Some themes are more developed than others

Table 2. Statement that contributed to more than one theme

Statements	Themes linked
43. Difficulty of removal (I)	• 15. Legal Liability for impacts to users of the sea (I) • 40. Balancing risks of leaving in the marine environment versus impact of disposing onshore tradeoffs (O) • 47. The 'value' is different to different people or groups e.g. the value to commercial fishers or recreational fishers is the commercial fish on the infrastructure but it could be value of the habitat to protect or support vulnerable species (I)
20. Hazard for users of ocean long term – degradation (environmental) (I)	• 15. Legal Liability for impacts to users of the sea (I) • 40. Balancing risks of leaving in the marine environment versus impact of disposing onshore tradeoffs (O) • 58. Unable to compare what was to what is to demonstrate benefits (big data gaps) (I)
34. Unknown future environmental hazards that the leaving of infrastructure in-situ may create	• 54. Unable to compare what was to what is to demonstrate benefits (big data gaps (I) • 15. Legal liability for impacts to users of the sea
52. Lack of understanding of impact of total removal on fishing populations (I)	• 24. Cumulative impacts of multiple structures (I) • 47. The 'value' is different to different people or groups e.g. the value to commercial fishers or recreational fishers is the commercial fish on the infrastructure but it could be value of the habitat to protect or support vulnerable species (O)

- Statement 20 given the extensiveness of links around it, could also be seen as a headline

Reviewing the values

- There emerged 12 values (with one of the headlines – 55 *bring benefit to local economy* being upgraded to a value).
- The values appeared to form a number of clusters namely
    - o legislation and clarity of liability (84 and 67),
    - o benefits to community/economy (55, 73, 70, 72, 71)
    - o developing new industry (76)
    - o integrated, collaborative systemic approach (80, 82 and 79)

Table 3. Rating of importance of issues and opportunities as an oil and gas employee

Theme	Average Rating (out of 10)	Degree of Consensus
58. Unable to compare what was to what is to demonstrate benefits (big data gaps) (I)	7.60	1.40
24. Cumulative impacts of multiple structures (I)	6.40	3.10
47. The 'value' is different to different people or groups e.g. the value to commercial fishers or recreational fishers is the commercial fish on the infrastructure but it could be value of the habitat to protect or support vulnerable species (I)	6.40	3.10
13. Provides valuable habitat (O)	5.80	2.70
15. Legal liability for impacts to users of the sea (I)	4.60	3.10
40. Balancing risks of leaving in the marine environment versus impact of disposing onshore tradeoffs (O)	3.00	2.40

The lower the number the greater the degree of consensus. As such Statement 58 not only had the highest average but also received the greatest degree of consensus.

Reflections from the Chevron Workshop

Reviewing the Issues and Opportunities

- 26 Opportunities and 25 Issues revealing an almost even balance between the two categories.

Table 4. Themes (headlines) and supporting issues and opportunities (identified through links)

Theme	Issues and Opportunities
27. Long term liability – who owns if proponent walks away (I)	11 (I), 19 (I), 42 (I)
41. Reduce the cost of decommissioning for proponents and general public government (O)	40 (O), 43 (O), 36 (O), 50 (I), 53 (O), 11 (I), 28 (I), 59 (I)
55. Understanding the cost-benefit economic life cycle analysis to capture short term benefits (smelting) offset against long term benefits (fisheries) (O)	51 (O), 44 (O), 23 (O), 31 (O)
25. Policy not able to keep pace with resource sharing issues (I)	58 (I), 35 (I), 57 (I)
13. Retain existing habitat for value (O)	38 (O), 22 (O), 17 (O), 26 (O), 44 (O)
45. Concerns re residual contamination of O&G structure (I)	9 (I)
10. Navigational hazard for general shipping (I)	12 (I), 56 (I)
14. Sharing of potential resources between user groups (I)	48 (I), 30 (O), 34 (O)
24. Potential for invasive species presence (I)	46 (I), 60 (I)
32. Potential fish populations not managed properly with fishing restrictions (I)	18 (I), 48 (I)

- The themes are not mutually exclusive – they share statements – representing the systemic nature.
- In some instances themes comprise both Issues and Opportunities demonstrating potential dilemmas. The theme concentrating on 'Reduce the cost of decommissioning' is one such theme
- Some themes are more developed than others

Table 5. Statement that contributed to more than one theme

Statements	Themes linked
11. Resourcing of infrastructure maintenance long term (I)	• 41. Reduce the cost of decommissioning for proponents and general public government (O) • 27. Long term liability – who owns if proponent walks away (I)
44. Reduce GHG associated with onshore disposal/smelting and instead have blue carbon potential (O)	• 55. Understanding the cost-benefit economic life cycle analysis to capture short term benefits (smelting) offset against long term benefits (fisheries) (O) • 13. Retain existing habitat for value (O)
48. Balancing access rights between competing user groups (I)	• Potential fish populations not managed properly with fishing restrictions (I) • Sharing of potential additional resources between user groups (I)

Reviewing the values

- There emerged 5 values
- The values straddled economic, environmental, and social considerations with the strongest emphasis on economics/cost.

Table 6. Rating of importance of issues and opportunities as a Chevron employee

Theme	Average Rating (out of 10)	Degree of Consensus
27. Long term liability – who owns if proponent walks away (I)	9.0	0.71
41. Reduce the cost of decommissioning for proponents and general public government (O)	8.30	1.90
55. Understanding the cost-benefit economic life cycle analysis to capture short term benefits (smelting) offset against long term benefits (fisheries) (O)	6.50	2.50
25. Policy not able to keep pace with resource sharing issues (I)	6.30	1.50
13. Retain existing habitat for value (O)	5.80	2.50
45. Concerns re residual contamination of O&G structure (I)	5.50	1.80
10. Navigational hazard for general shipping (I)	4.30	2.80
14. Sharing of potential resources between user groups (I)	3.50	3.30
24. Potential for invasive species presence (I)	3.30	1.80
32. Potential fish populations not managed properly with fishing restrictions (I)	3.0	0.71

Note that liability emerged as not only being the most important but also with the highest degree of consensus. Second was reducing the cost of decommissioning but with less consensus.

Next Steps

1. Conduct further 'workshops' with multiple stakeholder groups for example regulators, commercial fishing, Onslow, Karratha, and Busselton
2. Integrate, compare and contrast findings from all workshops along with material from a workshop undertaken with the steering committee and 2 undertaken with Exmouth participants
3. Develop a causal model depicting social values and man-made aquatic infrastructure within the West Australia context
4. Develop semi quantitative models including Multi-Criteria Decision Models to further assess and understand social value
5. Integrate workshop findings with findings from other parts of the research project (literature review, survey data, economic data etc.)

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

Online Regulator Workshop Feedback Report

Online Regulator Workshop Feedback Report

Online Regulator Workshop Feedback Report

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Executive Summary

As part of the research project focusing on "Enhancing the Understanding of the Value Provided to Fisheries by Man-Made Aquatic Structures" two online workshop were conducted with those involved with regulatory matters on the 18^{th} and 22^{nd} of May 2020. These workshop focused on exploring the issues and opportunities regarding man-made marine structures (MMS) along with determining social values associated with a prioritised subset of themes. The workshops, facilitated by Fran Ackermann, involved 12 participants in total and used an online computer – based system to capture, model and synthesise views. The report focuses purely on the material generated from the workshop and will be augmented with further online workshops, the results of a survey and various economic value assessment analyses.

This short report comprises of:

1. Project background
2. A brief overview of the method underpinning the workshops and outcomes
3. An overview maps detailing the, opportunities, issues and social values relating to MMS for both workshops
4. Reflections from both workshops
5. A list of project next steps regarding social value

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number CTR-10729).

Project Background

This project is a collaboration between the Fisheries Research and Development Corporation, Curtin University, The University of Western Australia and the West Australian Marine Science Institute to explore the socioeconomic values associated with MMS. The project has four aims:

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.

Initial findings from a literature review exploring social and economic values associated with MMS demonstrated that gaps exist within the current body of available research. These include: being discrete in nature, limited diversity of stakeholder view (e.g. focused on one or two groups only), limited specific exploration of MMS (e.g. natural reefs rather than artificial), and not being specifically applicable to a West Australian context (e.g. primarily from other states or countries). As such, using only existing literature to inform this research project would be insufficient.

In order to achieve our research aims the team are undertaking further data collection to including; holding online workshops using a group support system with people from Perth, Exmouth, Karratha, Onslow, and Busselton, creating and disseminating a survey for recreational fishers and divers, and determining the monetary value MMS generated by the structures and associated activities. Throughout the data collection process integration between social and economic findings will be undertaken to achieve a broad and well-informed picture of qualitative, semi-quantitative and quantitative aspects associated with MMS.

Brief Overview

Online Regulators Workshop One, 18th of May 2020

- Participant 1, Department of Mines, Industry Regulation and Safety
- Participant 2, Department of Mines, Industry Regulation and Safety
- Participant 3, Department of Water and Environmental Regulation
- Participant 4, Department of Primary Industries and Regional Development

Online Regulators Workshop Two, 22nd of May 2020

- Participant 1, Australian Petroleum Production and Exploration Association
- Participant 2, Department of Primary Industries and Regional Development
- Participant 3, Department of Industry, Science, Energy and Resources
- Participant 4, Department of Industry, Science, Energy and Resources
- Participant 5, Department of Industry, Science, Energy and Resources
- Participant 6, Department of Primary Industries and Regional Development
- Participant 7, NOPSEMA
- Participant 8, Department of Water and Environmental Regulation

Facilitators: Fran Ackermann, Euan Harvey and Georgie Hill

Overview

The workshops commenced with a brief introduction before focusing on "what are the issues and opportunities regarding man-made marine infrastructure?" Each participant was given the opportunity to contribute both Issues and Opportunities (denoted by 'I' or 'O') in relation to the focal question. Using a group mapping process, each participant could a) anonymously contribute, b) see their ideas alongside the contributions of others and c) 'piggyback' off one another. This provided a rich reservoir of contributions. This process generated 51 statements in the first workshop (18 Issues, 29 Opportunities and 4 statements that were considered both an issue and an opportunity) and 53 statements in the second (28 Issues, 22 Opportunities and 3 statements that were considered both an issues and an opportunity). The surfaced material was put into rough 'content oriented' clusters during the generation process and subsequently reviewed by the group allowing for new material to be surfaced as well as to ensure all were clear as to the meaning of the statements and statements were in the most appropriate cluster.

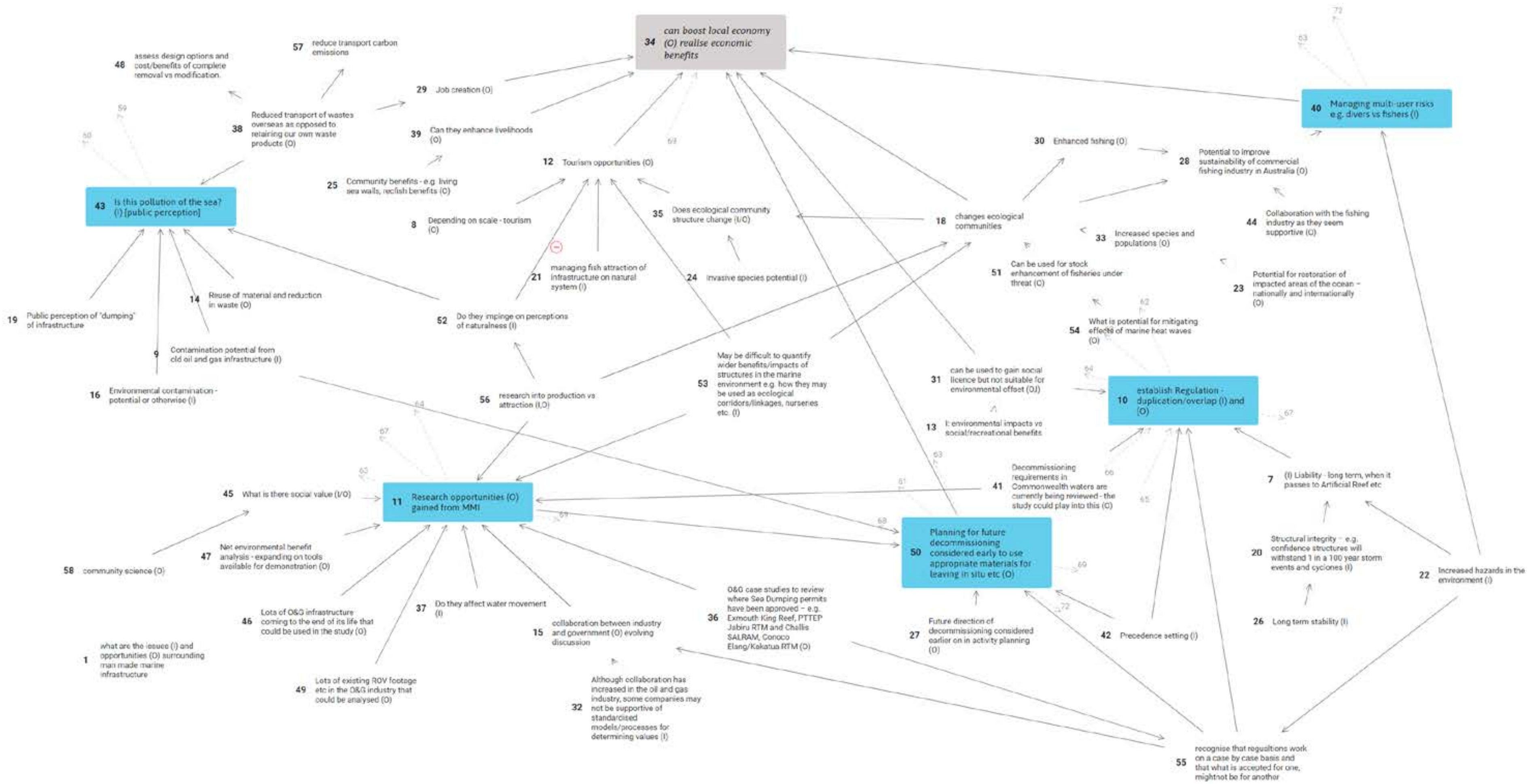
During the process of elaboration, it became clear statements impacted one another and so the process of causally linking the statements together was undertaken. This resulted in a 'map' of interconnected issues and opportunities helping tease out a nuanced and systemic representation reflecting the complexity of the topic. The linked clusters were subsequently re-reviewed and 'headline' statements identified and given a different style (blue box). Each headline represented a specific theme. Maps 1 and 2 shows the issues, opportunities and headline statements for each workshop.

To conclude the first part of the morning session, a prioritisation process was undertaken asking the participants to rate the headline statements (see Tables 3 and 6) taking into account the entire cluster.

After a brief break, the group reviewed the headline issues and explored the implications of each, i.e. what value they either supported (opportunities) or 'challenged' (issues). Each value identified was allocated a distinct style (grey box). Maps 3 and 4 showings the headline issues, values and interconnecting material.

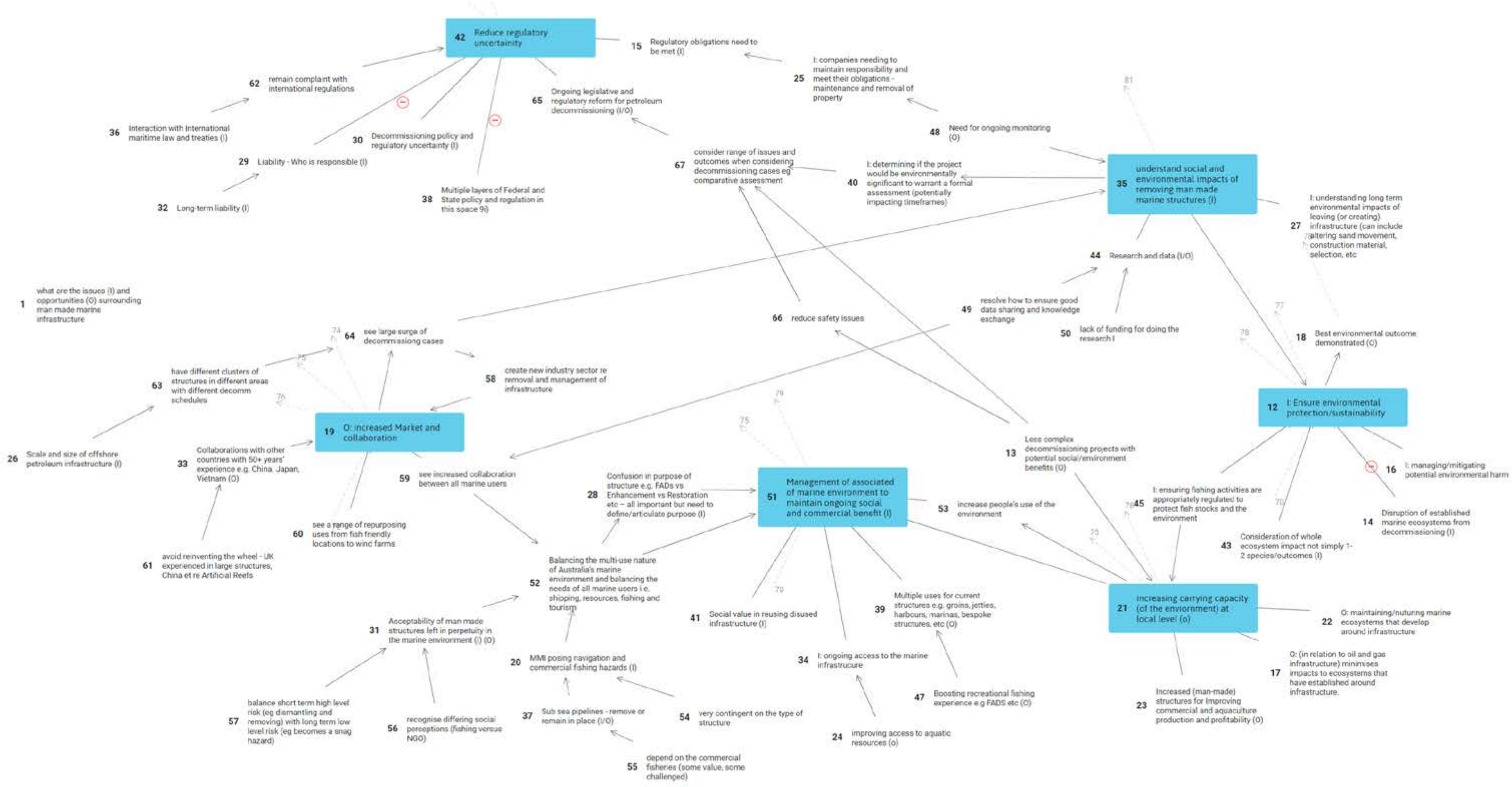
Maps of Issues, Opportunities and Social Values Associated with Man-Made Marine Infrastructure

Map 1. Issues and opportunities identified in the regulator workshop one



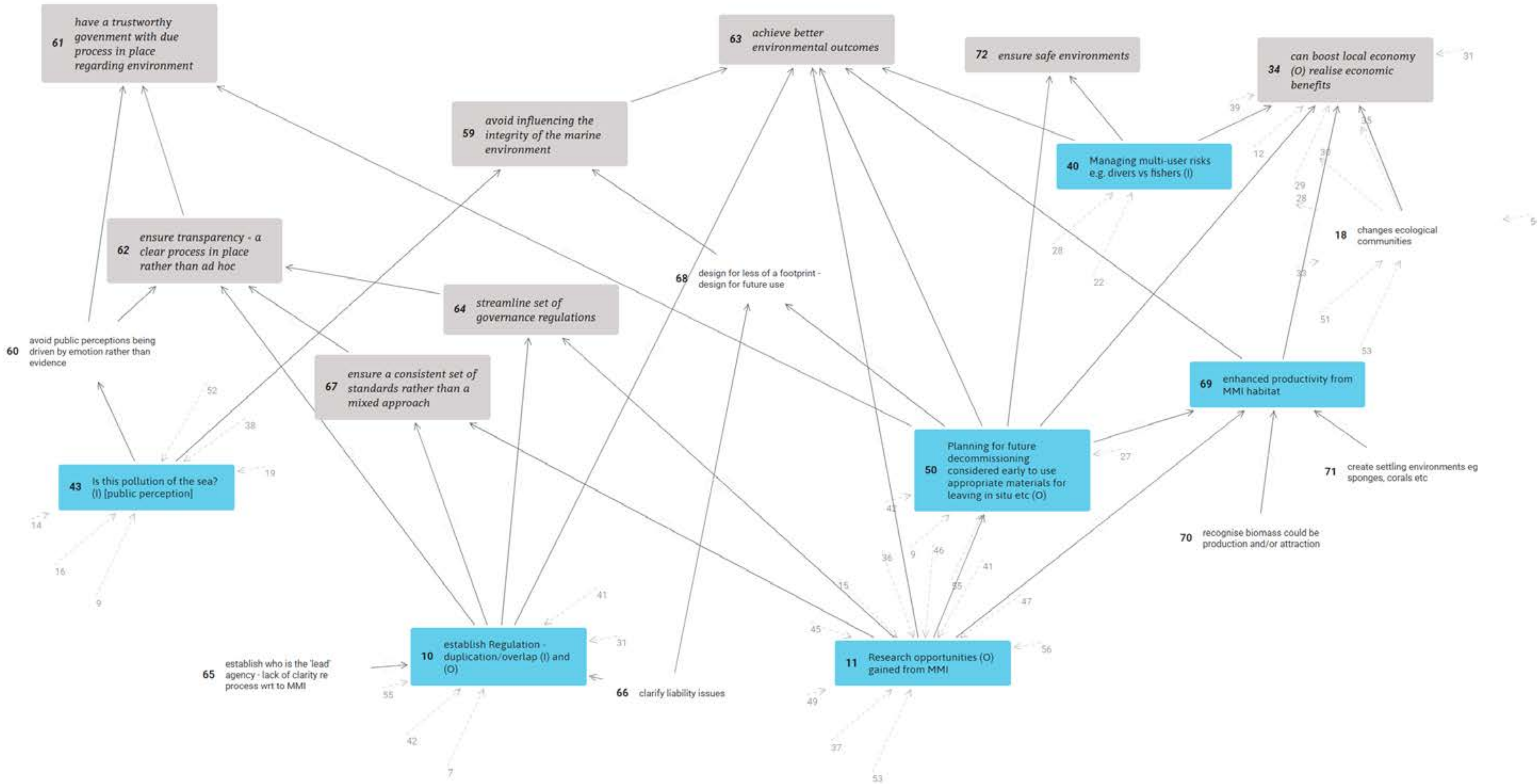
Note: 'Blue boxes' refer to headline statements and grey boxes the values. A minus sign on the arrowhead reflects a negative link

Map 2. Issues and opportunities identified in the regulator workshop two



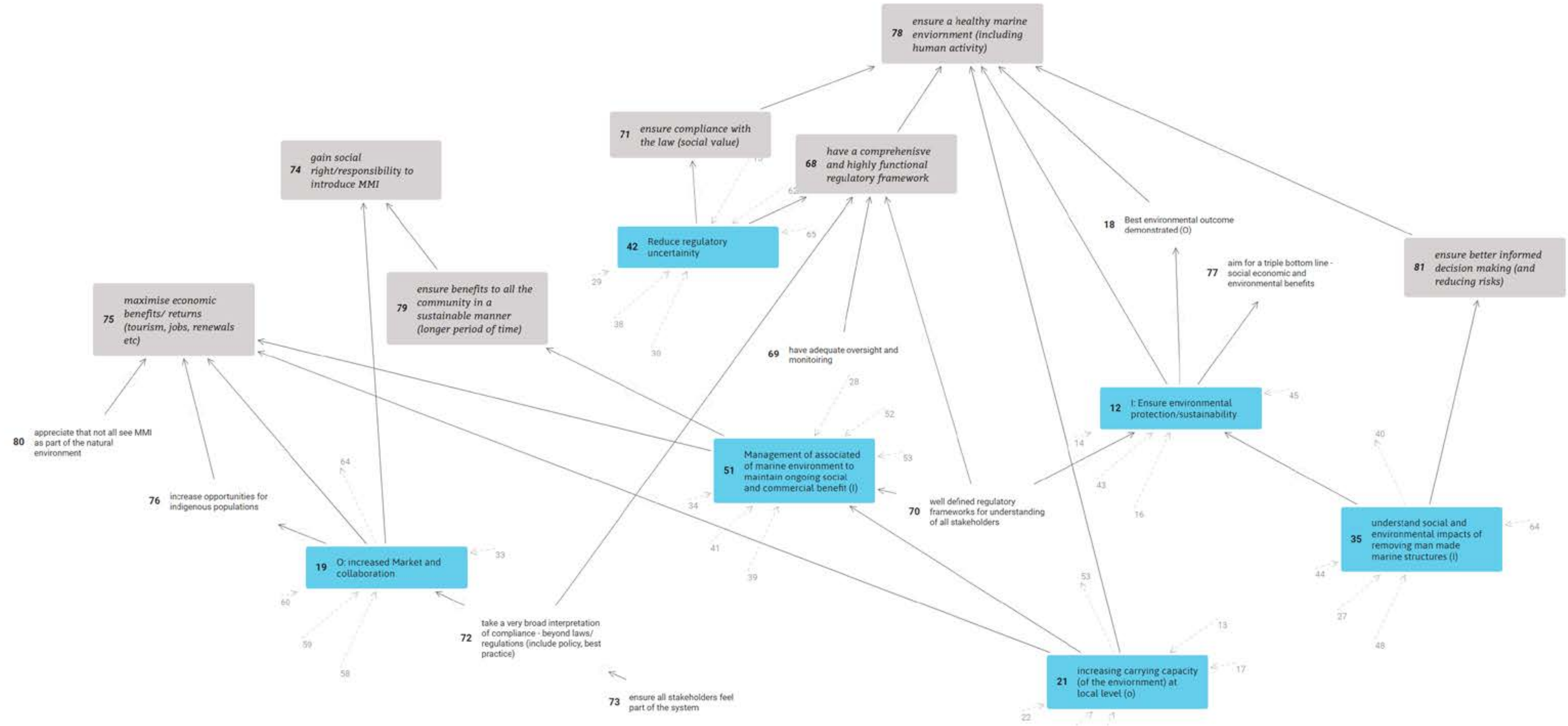
Note: 'Blue boxes' refer to headline statements. A minus sign on the arrowhead reflects a negative link

Map 3. Social values identified in the regulator workshop one



Note: 'Grey boxes' refer to social values. A minus sign on the arrowhead reflects the opposite.

Map 4. Social values identified in the regulator workshop two



Note: 'Grey boxes' refer to social values. A minus sign on the arrowhead reflects the opposite.

Reflections from the Regulator Workshop One

Reviewing the Issues and Opportunities

- There emerged 19 Issues and 32 Opportunities and 4 that were considered both an issues and an opportunity – revealing that there were more opportunities than there were issues.
- 5 themes/headlines existed

Table 1. Themes/clusters and number of linked issues and opportunities

Theme	Issues and Opportunities
11. Research opportunities gained from MMI (O)	45 (I/O), 47 (O), 46 (O), 49, (O), 37 (I), 15 (O), 36 (O), 53 (I), 56 (I/O), 41 (O), 32 (I), 55 (O)
10. Establish regulation - duplication/overlap (I) and (O)	65 (I), 66 (I), 31 (I/O), 41 (O), 42 (I), 55 (O), 7 (I), 13 (I), 50 (O), 22 (I), 20 (I), 36 (O)
43. Is this pollution of the sea? [public perception] (I)	19 (I), 16 (I), 9 (I), 14 (O), 52 (I), 38 (O), 56 (I/O)
50. Planning for future decommissioning considered early to use appropriate materials for leaving in situ etc. (O)	9 (I), 27 (O), 55 (O), 42 (I), 36 (O), 22 (I)
40. Managing multi-user risks e.g. divers vs fishers (I)	28 (O), 22 (I), 30 (O), 18 (O)

- The themes are not mutually exclusive – they share statements – representing the systemic nature.
- In all of the themes there were both Issues and Opportunities demonstrating potential dilemmas.
- Some themes are more developed than others – particularly of note were 'Research opportunities gained from MMI' and 'Establish regulation - duplication/overlap'

Table 2. Statements that contributed to more than one theme through links

Statements	Themes linked
9. Contamination potential from old oil and gas infrastructure (I)	• 43. Is this pollution of the sea? [public perception] (I) • 50. Planning for future decommissioning considered early to use appropriate materials for leaving in situ etc. (O)
22. Increased environmental hazard (I)	• 10. Establish regulation - duplication/overlap (I) and (O) • 50. Planning for future decommissioning considered early to use appropriate materials for leaving in situ etc. (O) • 40. Managing multi-user risks e.g. divers vs fishers (I)
36. O&G case studies to review where sea dumping permits have been approved – e.g. Exmouth king reef PTTEP Jabiru, RTM and challis SALRAM, Conoco Elang/Kakatua RTM (O)	• 11. Research opportunities gained from MMI (O) • 10. Establish regulation - duplication/overlap (I) and (O) • 50. Planning for future decommissioning considered early to use appropriate materials for leaving in situ etc. (O)
41. Decommissioning requirements in Commonwealth waters are currently being reviewed – the study could play into this (O)	• 11. Research opportunities gained from MMI (O) • 10. Establish regulation - duplication/overlap (I) and (O)
42. Precedence setting (I)	• 10. Establish regulation - duplication/overlap (I) and (O) • 50. Planning for future decommissioning considered early to use appropriate materials for leaving in situ etc. (O)
55. Recognise that regulations work on a case by case basis and that what is acceptable for one might not be acceptable for another (O)	• 11. Research opportunities gained from MMI (O) • 10. Establish regulation - duplication/overlap (I) and (O) • 50. Planning for future decommissioning considered early to use appropriate materials for leaving in situ etc. (O)
56. Research into production vs attraction (I/O)	• 11. Research opportunities gained from MMI (O) • 43. Is this pollution of the sea? [public perception] (I)

- Statements contributing to >1 theme are potentially 'potent' that is they have considerable contribution.

Reviewing the values

- There emerged 8 values.
- That the values appeared to form clusters relating to standards and regulations, environmental outcomes and local economy

Table 3. Rating of importance of issues and opportunities

Theme	Average Rating (out of 10)	Degree of Consensus
11. Research opportunities gained from MMI (O)	8.30	1.50
10. Establish regulation - duplication/overlap (I) and (O)	7.00	1.20
43. Is this pollution of the sea? [public perception] (I)	6.80	1.60
50. Planning for future decommissioning considered early to use appropriate materials for leaving in situ etc. (O)	6.50	1.70
40. Managing multi-user risks e.g. divers vs fishers (I)	6.50	2.10

Reflections from the Regulator Workshop Two

Reviewing the Issues and Opportunities

- There emerged 28 Issues and 22 Opportunities and 3 that were considered both an issues and an opportunity suggesting a relatively even mix.
- There emerged 6 themes

Table 4. Themes/clusters and number of directly linked issues and opportunities

Theme	Issues and Opportunities
12. Ensure environmental protection/sustainability (I)	45 (I), 43 (I), 14 (I), 16 (I),
35.Understand social and environmental impacts of removing man made marine structures (I)	27 I(), 48 (O), 44 (O), 64 (O)
42. Reduce regulator uncertainty (O)	62 (I), 29 (I), 30 (I), 38 (I), 65 (I/O), 15 (I), 36 (I), 25 (I)
19. Increased market and collaboration (O)	33 (O), 60 (O), 59 (O), 72 (I), 58 (O), 61 (I), 49 (O), 63 (I), 64 (O), 68 ()
51. Management of associated of marine environment to maintain ongoing social and commercial benefit (I)	52 (I), 28 (I), 41 (I), 34 (), 39 (O), 53 (I), 59 (O), 31 (I/O), 20 (I), 24 (O), 47 (O),
21. Increasing carrying capacity (of the environment) at local level (O)	13 (O), 23 (O), 17 (O), 22 (O), 45 (I)

- Themes not independent of one another instead they influenced and impacted one another. Some themes were quite extensive e.g. 51 Management of associated of marine environment to maintain ongoing social and commercial benefit (I)
- Themes were augmented with additional material during the discussions – those without I or O appended

Table 5. Statement that contributed to more than one theme

Statements	Themes linked
45. Ensuring fishing activities are appropriately regulated to protect fish stocks and the environment (I)	• 12. Ensure environmental protection/sustainability (I) • 21. Increasing carrying capacity (of the environment) at local level (O)
59. See increased collaboration between all marine users (O)	• 19. Increased market and collaboration (O) • 51. Management of associated of marine environment to maintain ongoing social and commercial benefit (I)
64. See large surge of decommissioning cases (O)	• 35.Understand social and environmental impacts of removing man made marine structures (I) • 19. Increased market and collaboration (O)

- Statements contributing to >1 theme are potentially 'potent' that is they have considerable contribution.

Reviewing the values

- 7 values forming 'apparent clusters'. For example, regulatory, marine environmental health, quality of decision making, community benefit and economic benefits.

Table 6. Rating of importance of issues and opportunities

Theme	Average Rating (out of 10)	Degree of Consensus
12. Ensure environmental protection/sustainability (I)	9.40	0.86
35. Understand social and environmental impacts of removing man made marine structures (I)	8.60	1.90
42. Reduce regulator uncertainty (O)	8.00	1.70
19. Increased market and collaboration (O)	6.40	2.50
51. Management of associated of marine environment to maintain ongoing social and commercial benefit (I)	5.80	3.10
21. Increasing carrying capacity (of the environment) at local level (O)	5.50	2.20

Next Steps

1. Conduct further 'workshops' with multiple stakeholder groups for example regulators, commercial fishing, Onslow, Karratha, and Busselton
2. Integrate, compare and contrast findings from all workshops along with material from a workshop undertaken with the steering committee and 2 undertaken with Exmouth participants
3. Develop a causal model depicting social values and man-made aquatic infrastructure within the West Australia context
4. Develop semi quantitative models including Multi-Criteria Decision Models to further assess and understand social value
5. Integrate workshop findings with findings from other parts of the research project (literature review, survey data, economic data etc.)

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

Online Recreational Fishing Workshop Feedback Report

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Executive Summary

As part of the research project focusing on "Enhancing the Understanding of the Value Provided to Fisheries by Man-Made Aquatic Structures" an online workshop was held on the 9th June. This workshop focused on exploring the issues and opportunities regarding man-made marine structures (MMS) along with determining social values associated with a prioritised subset of themes. The workshops, facilitated by Fran Ackermann and supported by Euan Harvey and Georgie Hill, involved a number of participants and used an online computer – based system to capture, model and synthesise views. This report focuses purely on the material generated from the workshops, however, this material will be integrated with material from other online workshops and those conducted face to face, as well as with the results of a survey and various economic value assessment analyses.

This short report comprises of:

1. Project Background
2. A brief overview of the method underpinning the workshops and outcomes
3. An overview map detailing the, opportunities, issues and social values relating to MMS for both workshops
4. A list of project next steps regarding social value

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number CTR-10729).

Project Background

This project is a collaboration between the Fisheries Research and Development Corporation, Curtin University, The University of Western Australia and the West Australian Marine Science Institution to explore the socioeconomic values associated with MMS. The project has four aims:

9. 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.
10. 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.
11. 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.
12. 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.

Initial findings from a literature review exploring social and economic values associated with MMS demonstrated that gaps exist within the current body of available research. These include: being discrete in nature, limited diversity of stakeholder view (e.g. focused on one or two groups only), limited specific exploration of MMS (e.g. natural reefs rather than artificial), and not being specifically applicable to a West Australian context (e.g. primarily from other states or countries). As such, using only existing literature to inform this research project would be insufficient.

In order to achieve our research aims the team are undertaking further data collection including holding online workshops with people from Perth, Exmouth, Karratha, Onslow, and Busselton, creating and disseminating a survey for recreational fishers and divers, and determining the monetary value MMS generated by the structures and associated activities. Throughout the data collection process integration between social and economic findings will be completed to achieve a broad and well-informed picture of qualitative, semi-quantitative and quantitative aspects associated with MMS.

Brief Overview

Online Recreational Fishing Workshop, 9th June 2020

- Participant 1
- Participant 2
- Participant 3
- Participant 4
- Participant 5
- Participant 6

Facilitators: Fran Ackermann, Euan Harvey

Overview

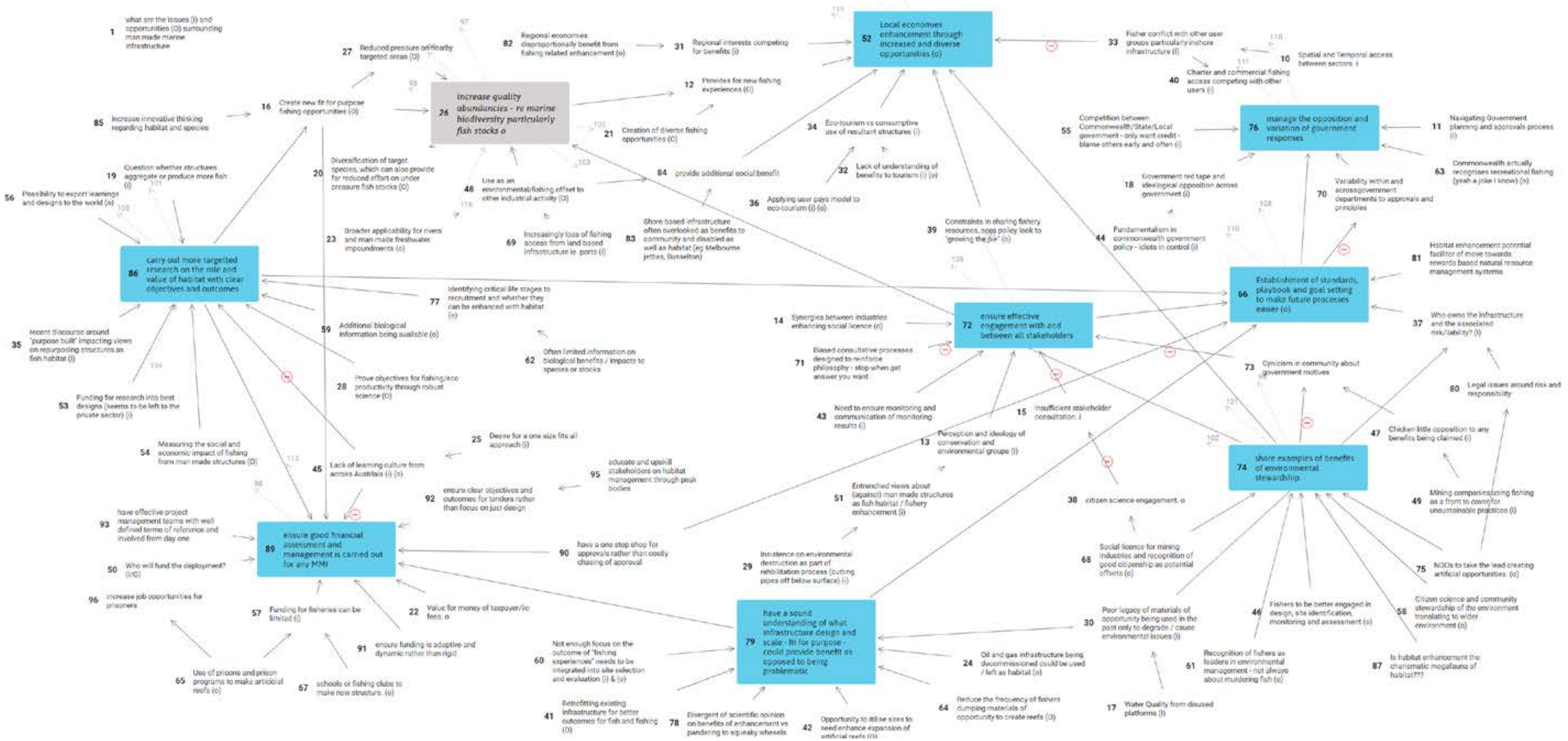
The workshop focused on "what are the issues and opportunities regarding man-made marine infrastructure?" Each participant was given the opportunity to contribution both Issues and Opportunities (denoted by 'I' or 'O') in relation to the focal question. Using a group mapping process, each participant could anonymously contribute to the focal question, seeing their ideas and the contributions of others on their screen and thus 'piggyback' off one another providing a rich reservoir of contributions. The surfaced material was put into rough 'content oriented' clusters and subsequently reviewed by the group allowing for new material to be surfaced as well as to ensure all were clear as to the meaning of the statements.

During the process of elaboration, it became clear that a number of the statements impacted others and so the process of causally linking the statements together was undertaken. This resulted in a 'map' of interconnected issues and opportunities helping tease out a rich picture of the statements along with their systemic properties reflecting the complexity of the topic The linked clusters were reviewed and 'headline' statements identified and given a different style (blue box). Each represented a specific theme. Map 1 shows the issues, opportunities and headline statements.

To conclude the first part of the morning session, a prioritisation process was undertaken asking the participants to rate the headline statements (see Table).

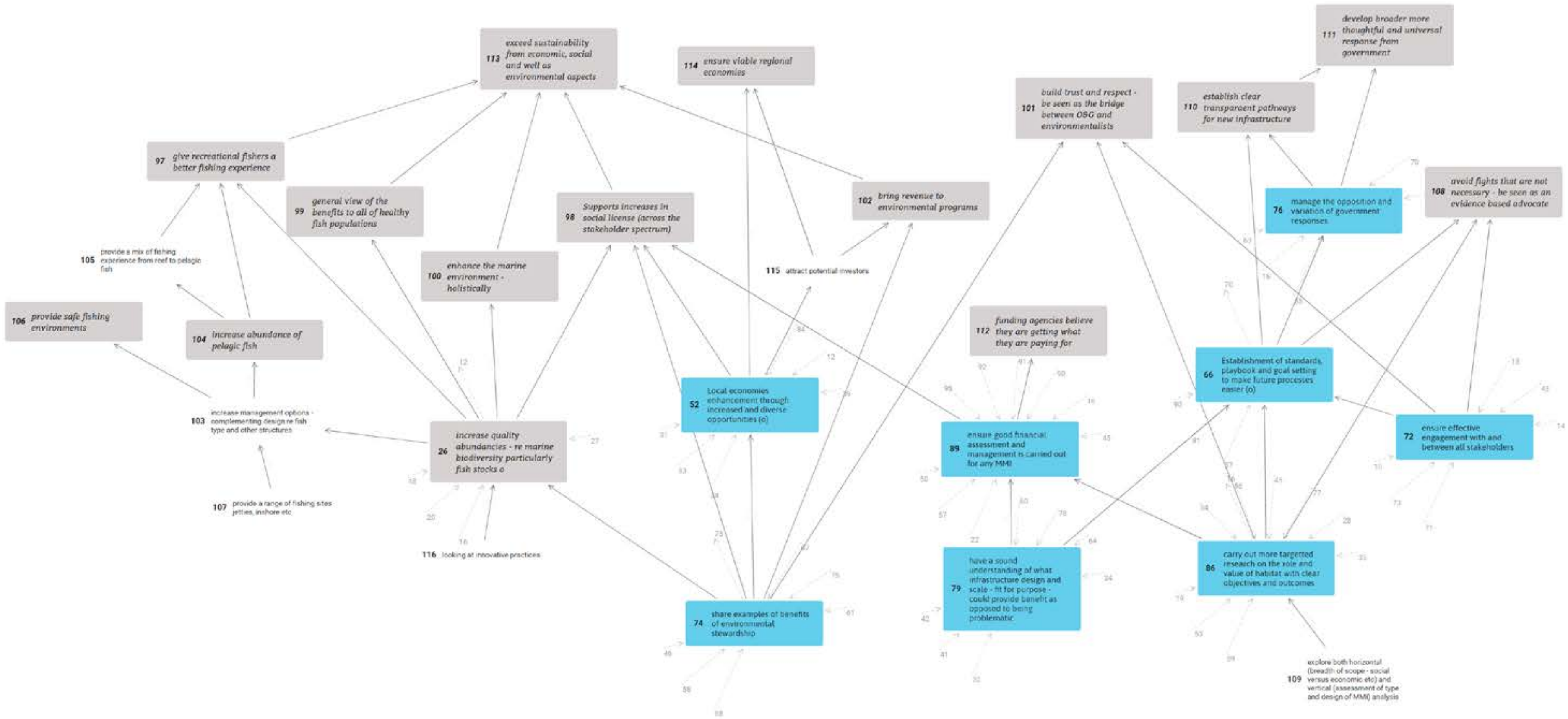
Results. After a brief break, the group reviewed the headline issues and explored the implications of each, i.e. what value they either supported (opportunities) or attacked (issues). Each value was identified and given a particular attribute (grey box). Map 3 showings the headline issues, values and interconnecting material.

Map 1. Issues and opportunities identified in the recreational fishing workshop



Note: 'Blue boxes' refer to headline statements. A minus sign on the arrowhead reflects a negative link

Map 2. Social values identified in the recreational fishing workshop



Note: 'Grey boxes' refer to social values. A minus sign on the arrowhead reflects the opposite.

Reflections from the Recreational Fishing Workshop

Reviewing the Issues and Opportunities

- Number of issues = 33, number of opportunities = 43, 6 of both issues and opportunities – revealing that participants believed …..

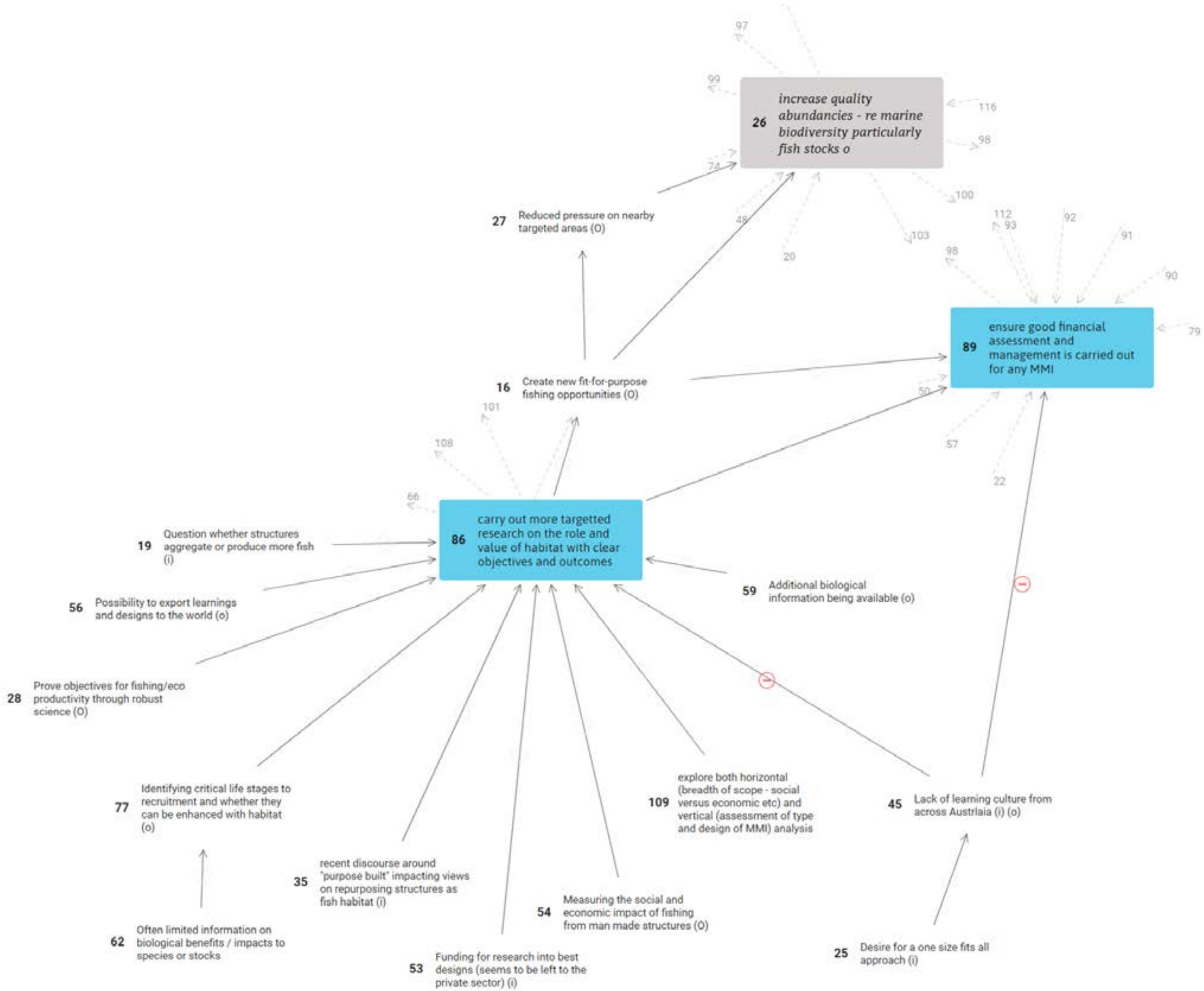
- The themes are not mutually exclusive – they share statements – representing the systemic nature.
- In many instances themes comprise both Issues and Opportunities demonstrating potential dilemmas.
- Some themes are more developed than others

Given the breadth of material detailed 'maps' of each theme are provided in Maps 3-9

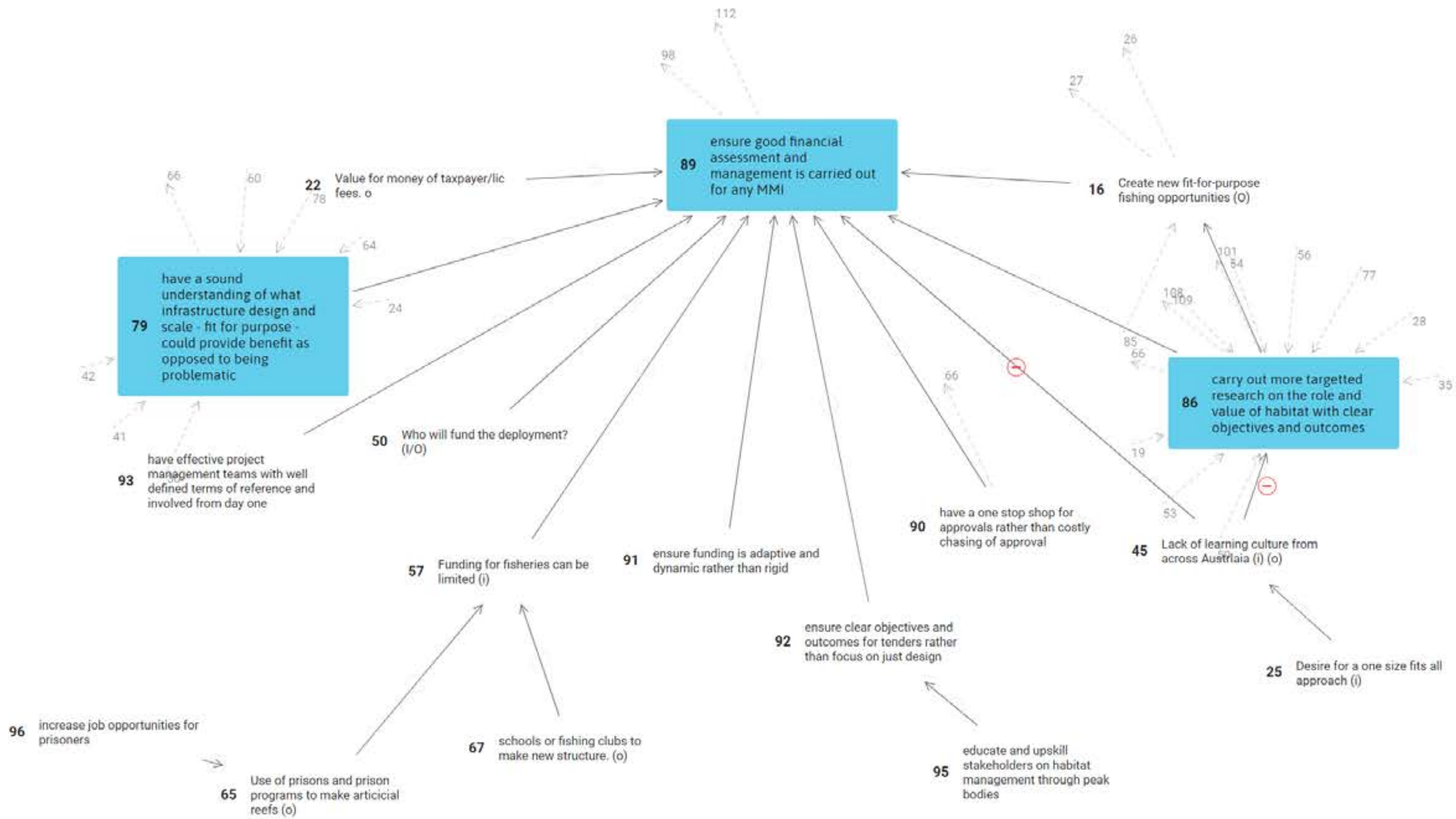
Reviewing the values

- There emerged 15 values (with one of the headlines – 26 *increase quality abundancies - re marine biodiversity particularly fish stocks (o)* being upgraded to a value).
- The values appeared to form a number of clusters namely
    - Regulatory transparency and evidence based policy (108, 111, 110),
    - Sustainability - from a range of perspectives (113,100, 98, 26, 104, 102, 99)
    - Economic viability (114)
    - Safety (106)
    - Trust (112, 101)
    - Improving fishing experience (97)
- Two statements namely 26. Increase quality abundancies - re marine biodiversity particularly fish stocks o and 86. Carry out more targeted research on the role and value of habitat with clear objectives and outcomes appear to be 'potent' contributing to 7 values

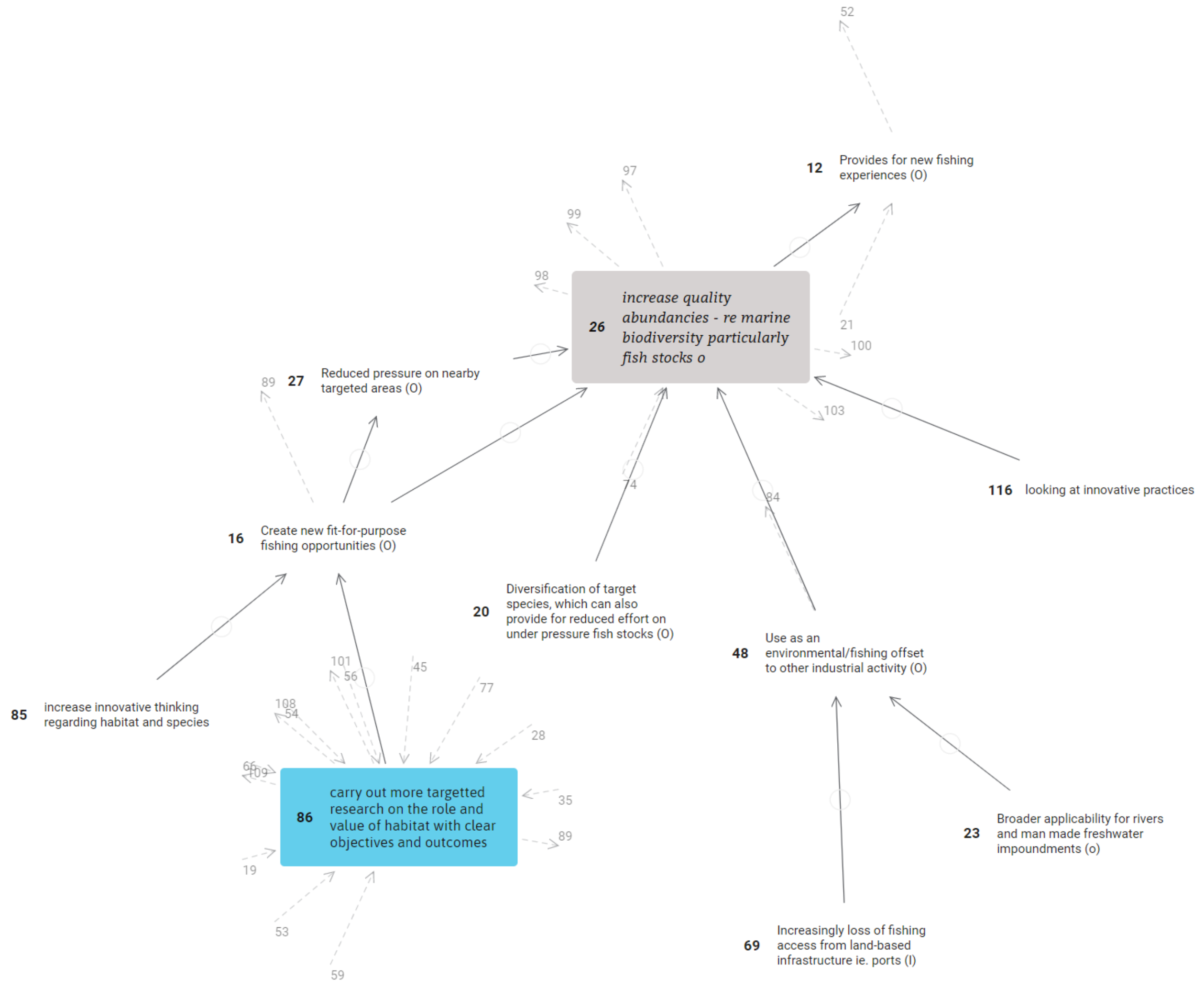
Map 3. Focus on 'carrying out more targeted research'



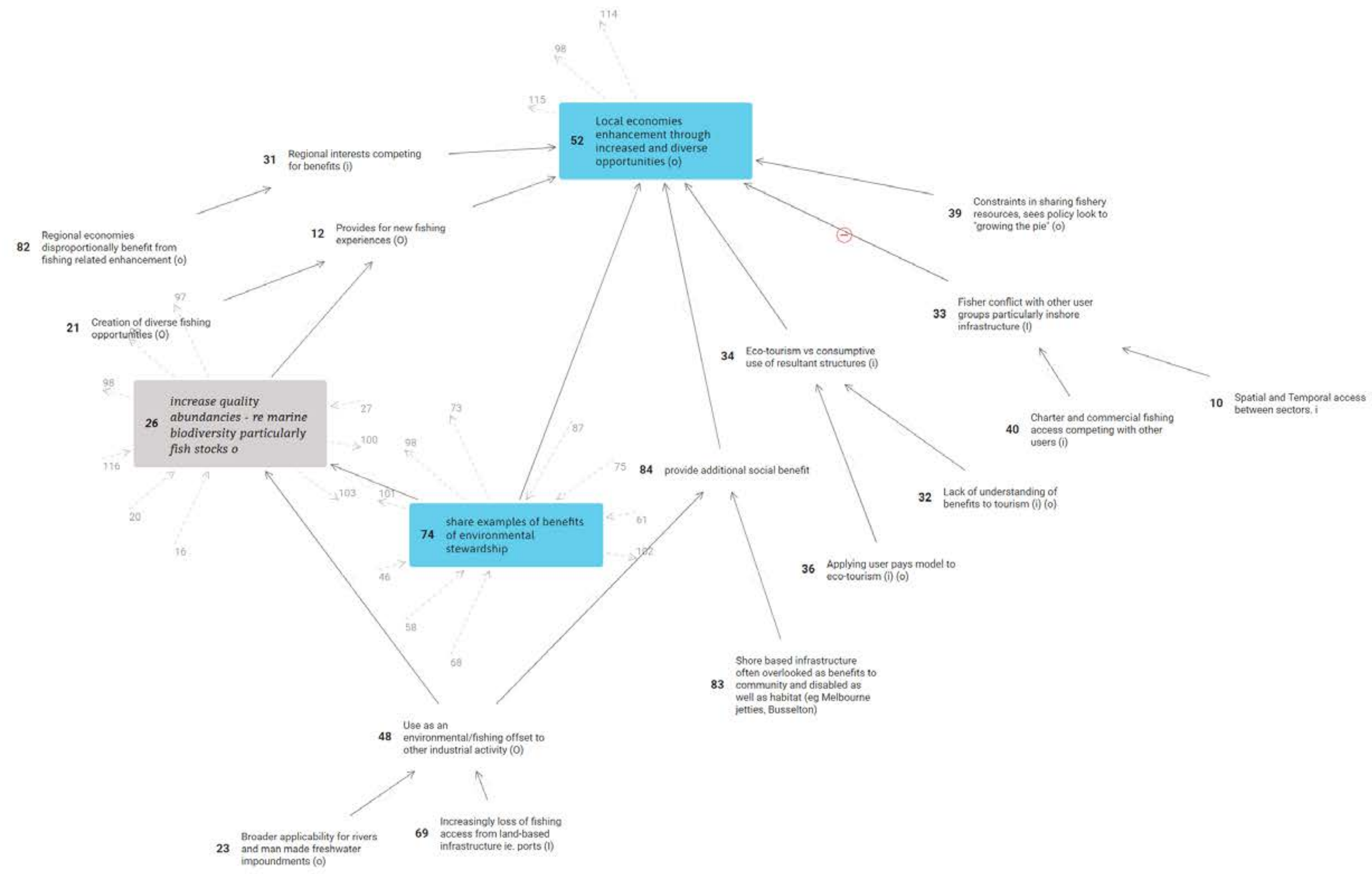
Map 4. Focus on 'ensuring good financial assessment and management'



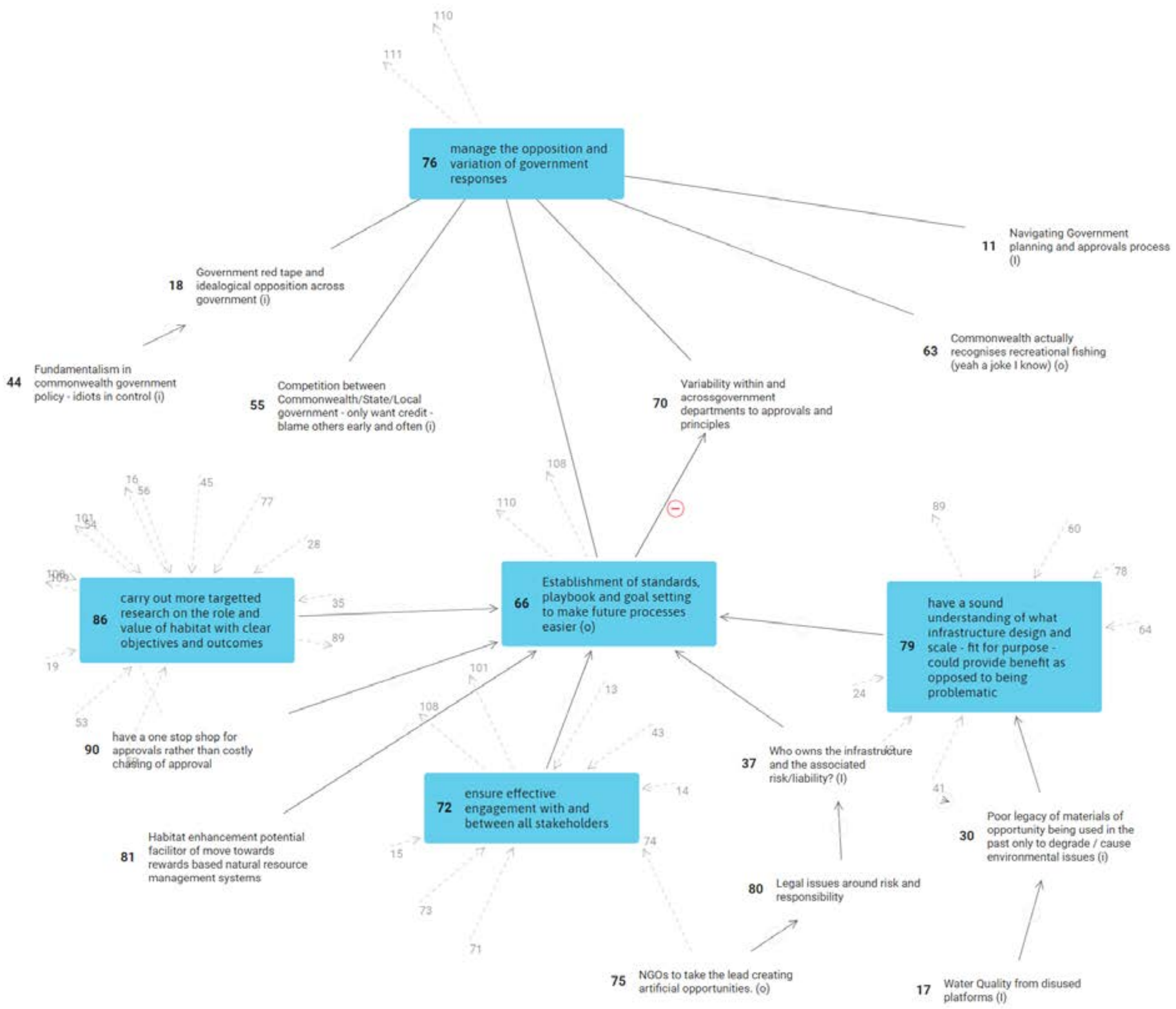
Map 5: focus on 'increasing quality and abundance'



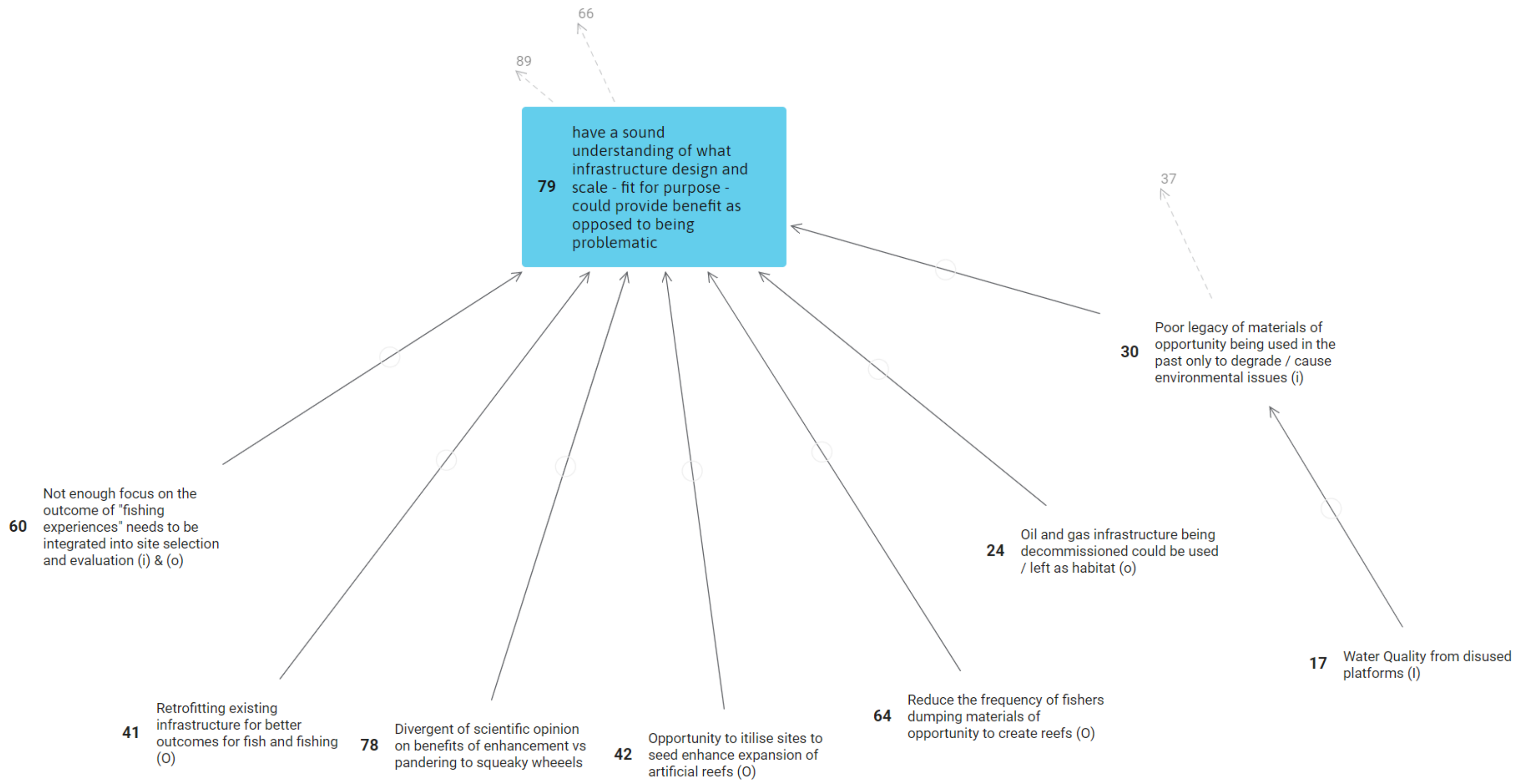
Map 6. Focus on 'economic enhancement'



Map 7. Focus on 'managing the opposition and variation of governmental responses' through 'establishing a playbook'



Map 8. Focus on 'having a sound understanding of infrastructure design'



Map 9. Focus on ‘ensuring effective engagement’ through ‘showing examples of environmental stewardship’

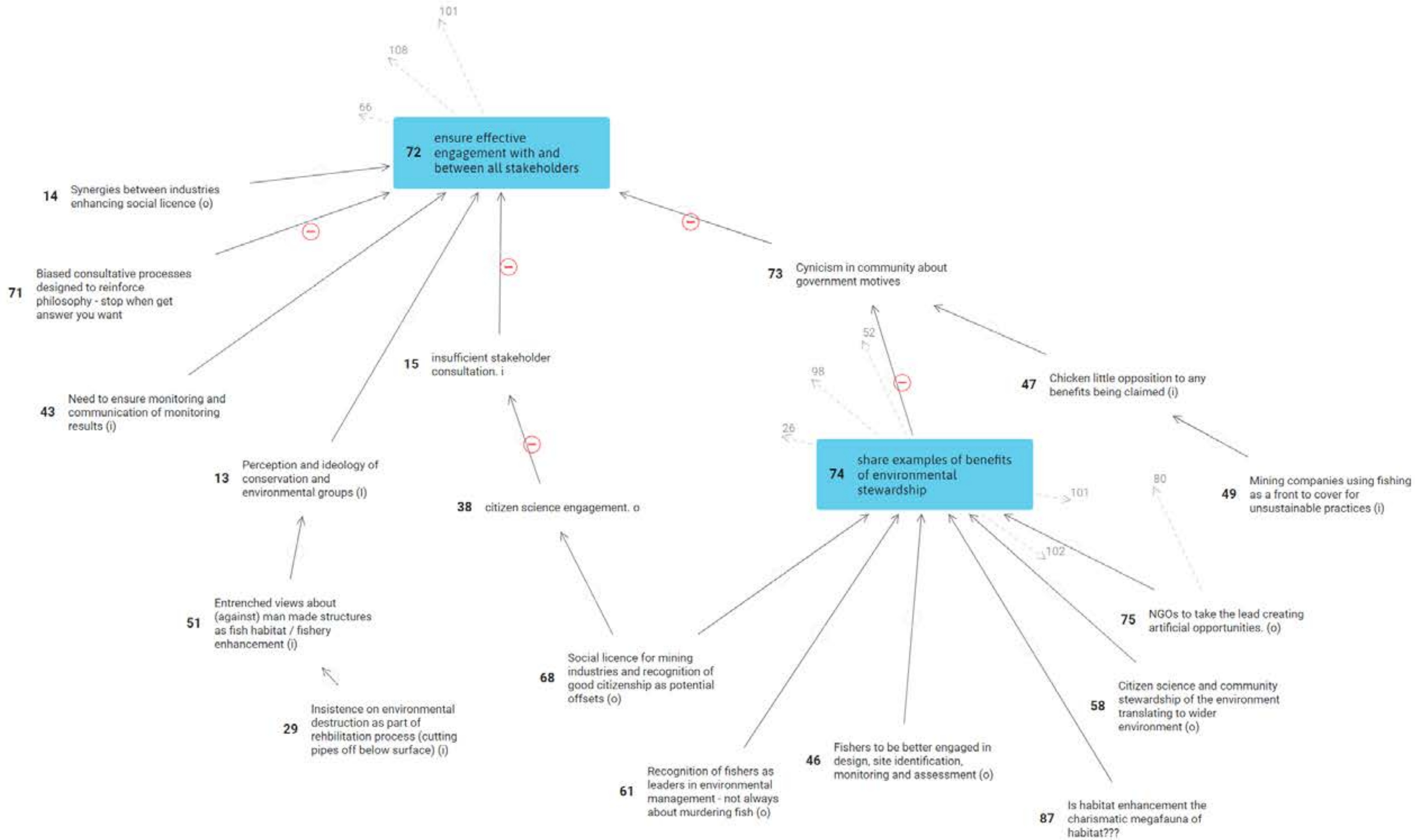


Table 1. Rating of importance of issues and opportunities from the perspective of recreational fishing

Theme	Average Rating (out of 10)	Degree of Consensus
79. Have a sound understanding of what infrastructure design and scale - fit for purpose - could provide benefit as opposed to being problematic	9.50	0.87
66. Establishment of standards, playbook and goal setting to make future processes easier (o)	8.80	0.83
72. Ensure effective engagement with and between all stakeholders	8.00	1.90
82. Local economies enhancement through increased and diverse opportunities (o)	7.80	0.83
26. Increase quality abundancies - re marine biodiversity particularly fish stocks o	7.30	2.70
74. Share examples of benefits of environmental stewardship	6.50	1.50
86. Carry out more targeted research on the role and value of habitat with clear objectives and outcomes	6.30	1.80
76. Manage the opposition and variation of government responses	6.30	2.90
89. Ensure good financial assessment and management is carried out for any MMI	5.00	3.20

Note: The lower the number the greater the degree of consensus. As such Statement 79 had the highest average. 66 and 82 received the greatest degree of consensus.

Next Steps

1. Conduct further ‘workshops’ with multiple stakeholder groups for example; commercial fishing, Onslow, Karratha, and Busselton
2. Integrate, compare and contrast findings from all workshops along with material from a workshop undertaken with the steering committee and 2 undertaken with Exmouth participants
3. Develop a causal model depicting social values and man-made aquatic infrastructure within the West Australia context
4. Develop semi quantitative models including Multi-Criteria Decision Models to further assess and understand social value
5. Integrate workshop findings with findings from other parts of the research project (literature review, survey data, economic data etc.)

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

Online Karratha and Onslow Workshop Feedback Report

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Executive Summary

As part of the research project focusing on “Enhancing the Understanding of the Value Provided to Fisheries by Man-Made Aquatic Structures” an online workshop was held on the 24th June with representatives from the Karratha and Onslow community. This workshop focused on exploring the issues and opportunities regarding man-made marine structures (MMS) along with determining social values associated with the prioritised themes. The workshops, facilitated by Fran Ackermann and supported by Euan Harvey and Georgie Hill, involved 4 participants and used an online computer – based system to capture, model and synthesise views. This report focuses purely on the material generated from the workshop, however, this material will be integrated with material from other online workshops and those conducted face to face, as well as with the results of a survey and various economic value assessment analyses.

This short report comprises of:

1. Project Background
2. A brief overview of the method underpinning the workshops and outcomes
3. An overview map detailing the opportunities, issues and social values relating to MMS including an appendix detailing each theme with its associated issues and opportunities
4. A list of project next steps regarding social value

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number CTR-10729).

Project Background

This project is a collaboration between the Fisheries Research and Development Corporation, Curtin University, The University of Western Australia and the West Australian Marine Science Institution to explore the socioeconomic values associated with MMS. The project has four aims:

13. 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.
14. 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.
15. 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.
16. 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.

Initial findings from a literature review exploring social and economic values associated with MMS demonstrated that gaps exist within the current body of available research. These include: being discrete in nature, limited diversity of stakeholder view (e.g. focused on one or two groups only), limited specific exploration of MMS (e.g. natural reefs rather than artificial), and not being specifically applicable to a West Australian context (e.g. primarily from other states or countries). As such, using only existing literature to inform this research project would be insufficient.

In order to achieve our research aims the team are undertaking further data collection including holding online workshops with people from Perth, Exmouth, Karratha, Onslow, and Busselton, creating and disseminating a survey for recreational fishers and divers, and determining the monetary value MMS generated by the structures and associated activities. Throughout the data collection process integration between social and economic findings will be completed to achieve a broad and well-informed picture of qualitative, semi-quantitative and quantitative aspects associated with MMS.

Brief Overview

Online Recreational Fishing Workshop, 24th June 2020

- Participant 1
- Participant 2
- Participant 3
- Participant 4

Facilitators: Fran Ackermann, Euan Harvey, Georgie Hill

Overview

The workshop focused on "what are the issues and opportunities regarding man-made marine infrastructure?" Each participant was given the opportunity to contribute both Issues and Opportunities (denoted by 'I' or 'O') in relation to the focal question. Using a group mapping process, each participant could anonymously contribute to the focal question, seeing their ideas and the contributions of others on their screen and thus 'piggyback' off one another providing a rich reservoir of contributions. The surfaced material was put into rough 'content oriented' clusters and subsequently reviewed by the group allowing for new material to be surfaced as well as to ensure all were clear as to the meaning of the statements.

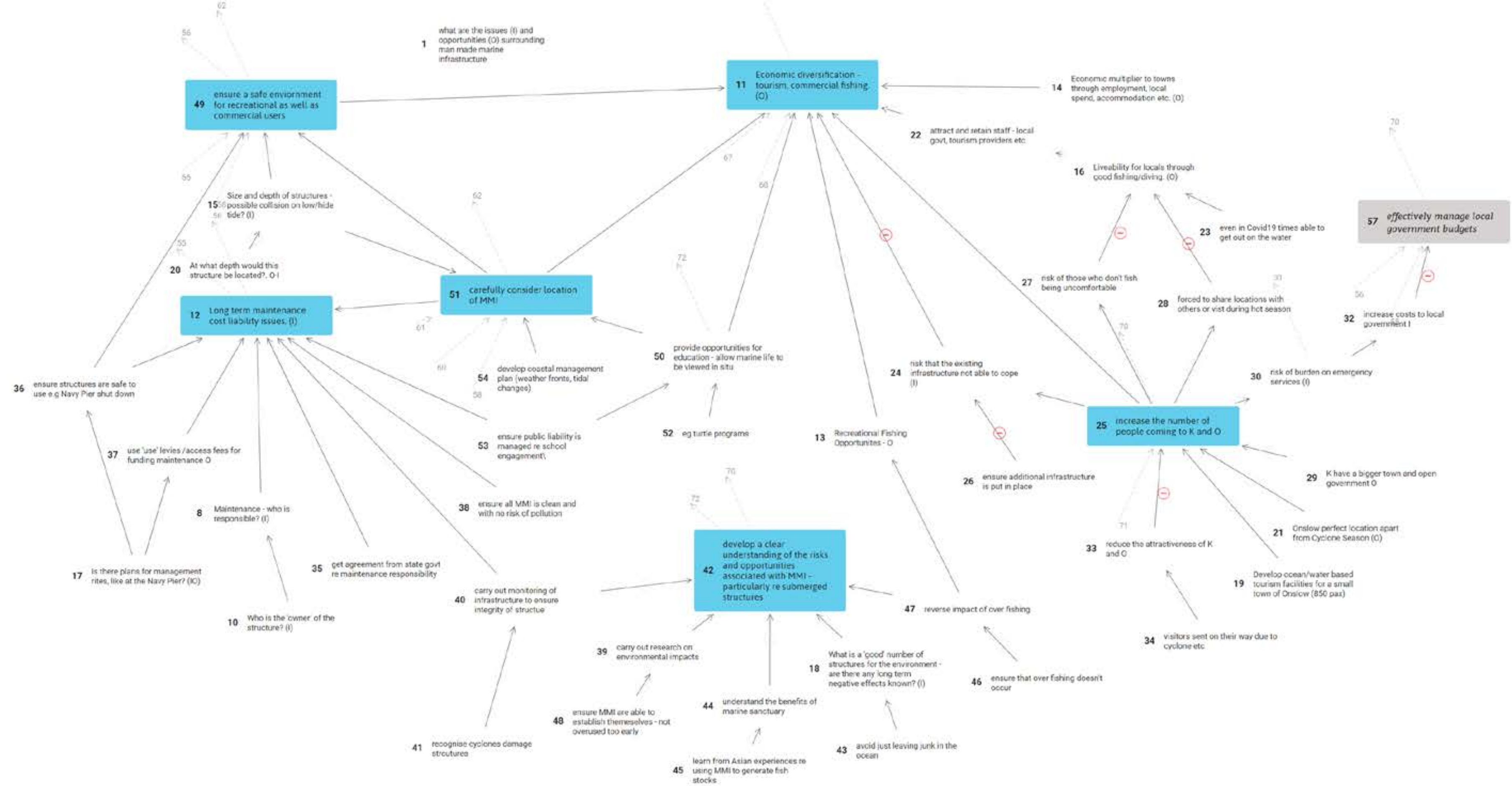
During the process of elaboration, it became clear that a number of the statements impacted others and so the process of causally linking the statements together was undertaken. This resulted in a 'map' of interconnected issues and opportunities helping tease out a rich picture of the statements along with their systemic properties reflecting the complexity of the topic The linked clusters were reviewed and 'headline' statements identified and given a different style (blue box). Each represented a specific theme. Map 1 shows the issues, opportunities and headline statements.

To conclude the first part of the morning session, a prioritisation process was undertaken asking the participants to rate the headline statements (see Table 1).

Results. After a brief break, the group reviewed the headline issues and explored the implications of each, i.e. what value they either supported (opportunities) or attacked (issues). Each value was identified and given a particular attribute (grey box). Map 3 showings the headline issues, values and interconnecting material.

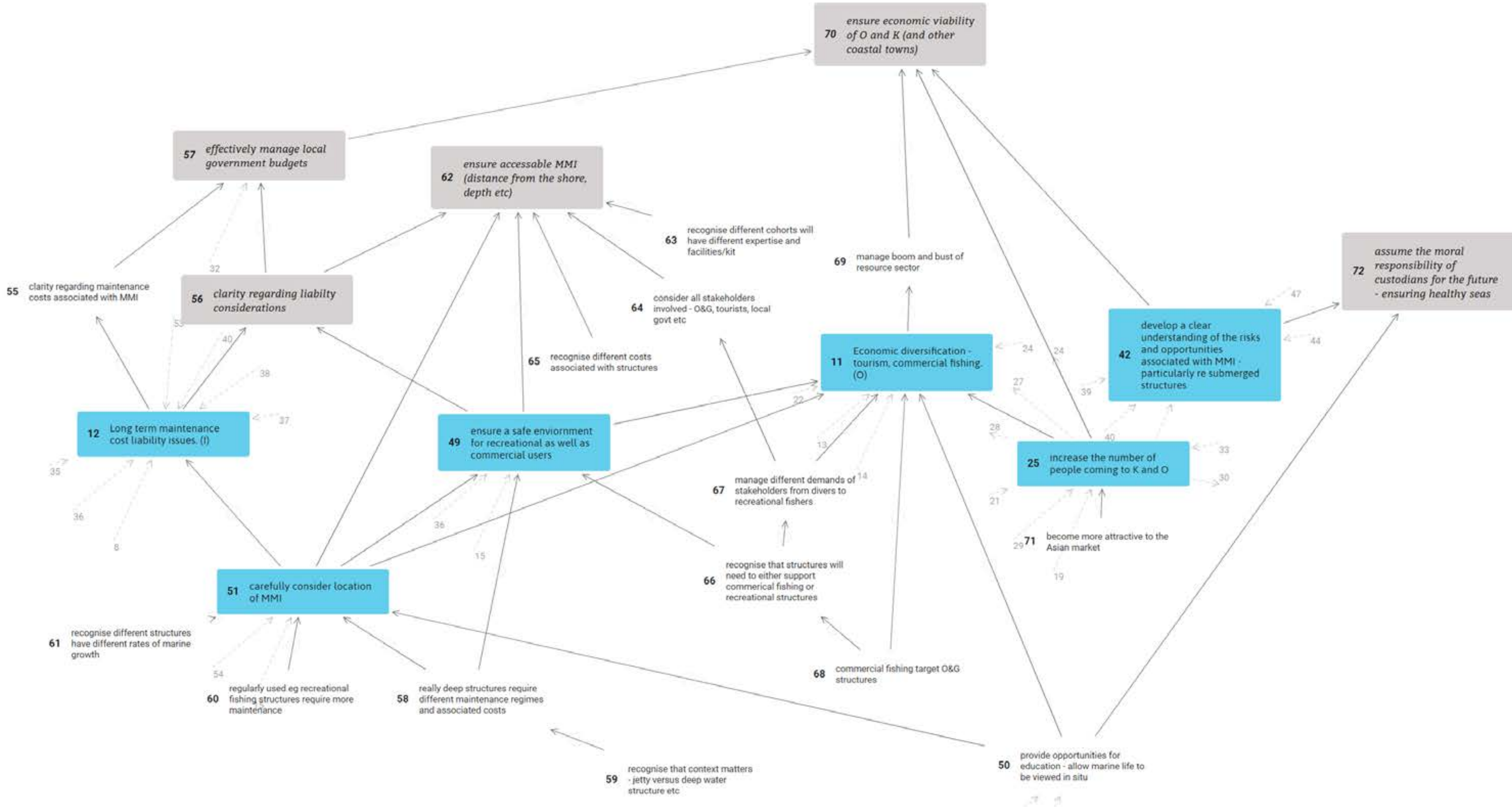
Maps of Issues, Opportunities and Social Values Associated with Man-Made Marine Structures

Map 1. Issues and opportunities identified in the Karratha and Onslow workshop



Note: 'Blue boxes' refer to headline statements. A minus sign on the arrowhead reflects a negative link

Map 2. Social values identified in the Karratha and Onslow workshop



Note: 'Grey boxes' refer to social values. A minus sign on the arrowhead reflects the opposite.

Reflections from the Karratha and Onslow Workshop

Reviewing the Issues and Opportunities

- Number of issues =19, number of opportunities = 20, 5 of both issues and opportunities – revealing that participants tended to view man-made marine infrastructure ….
- The themes are not mutually exclusive – they share statements – representing the systemic nature inherent in considering MMS
- In many instances themes comprise both Issues and Opportunities demonstrating potential dilemmas.
- Some themes are more developed than others. For example 49 – safe environment – has only 3 statements supporting it (and it is linking to only 1 other statement). 11 – economic diversification – however has not only a large number of statements (issues and opportunities) linking to it but also 3 other themes
- There are a number of issues/opportunities that impact more than 1 theme e.g. 40 carry out monitoring of infrastructure to ensure integrity of structure, 36 ensure structures are safe to use e.g Navy Pier shut down, 53 ensure public liability is managed re school engagement, and 47 reverse impact of over fishing.
- There were a number of instances where an issue or opportunity would negatively impact a theme e.g. 28 forced to share locations with others or visit during hot season, which potentially had a negative effect on 16 Liveability for locals through good fishing/diving (O). Thus increasing the number of visitors coming to Karratha and Onslow has both positive and negative consequences when considering the economic diversity theme.

Reviewing the values

- There emerged 5 values ranging from economic diversification to accessibility, from moral responsibility to clarity regarding liability and local budgets.
- Whilst the theme relating to 'safe environment' (49) did not have much in terms of material supporting it, its impact on the values was considerable as it either directly or indirectly impacted 4 of the 5 values. In addition, because it was linked to 49, 51 – careful consideration of location also contributed to 4 of the 5 goals as did 12 – maintenance issues.
- The headline considered to be the most important namely 42 only addressed two of the values.

Table 1. Rating of importance of issues and opportunities from the perspective of Karratha and Onslow

Theme	Average Rating (out of 10)	Degree of Consensus
49. Ensure a safe environment for recreational as well as commercial users	8.00	2.30
42. Develop a clear understanding of the risks and opportunities associated with MMI - particularly re submerged structures	7.50	1.50
51. Carefully consider location of MMI	6.50	1.50
12. Long term maintenance cost liability issues (I)	5.80	2.20
11. Economic diversification - tourism, commercial fishing. (O)	5.30	6.30
25. Increase the number of people coming to K and O	5.00	1.90

Note: The lower the number the greater the degree of consensus.

As such Statement 49 *safe environment* - had the highest average. 42 *clear understanding* and 51 *carefully consider location* received the greatest degree of consensus with 42 also having the second highest average.

Next Steps

1. Conduct further ‘workshops’ with additional stakeholder groups for example; commercial fishing, and Busselton
2. Integrate, compare and contrast findings from all workshops along with material from a workshop undertaken with the steering committee and 2 undertaken with Exmouth participants
3. Develop a causal model depicting social values and man-made aquatic infrastructure within the West Australia context
4. Develop semi quantitative models including Multi-Criteria Decision Models to further assess and understand social value
5. Integrate workshop findings with findings from other parts of the research project (literature review, survey data, economic data etc.)

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

Online Busselton Workshop Feedback Report

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Executive Summary

As part of the research project focusing on "Enhancing the Understanding of the Value Provided to Fisheries by Man-Made Aquatic Structures" an online workshop was held on the 14th July with representatives from the Busselton community. This workshop focused on exploring the issues and opportunities regarding man-made marine structures (MMS) along with determining social values associated with the prioritised issue/opportunity themes. The workshop, facilitated by Fran Ackermann and supported by Euan Harvey and Georgie Hill, involved 4 participants and used an online computer – based system to capture, model and synthesise views. This report focuses purely on the material generated from the workshop, however, this material will be integrated with material from other online workshops and those conducted face to face, as well as with the results of a survey and various economic value assessment analyses.

This short report comprises of:

1. Project Background
2. A brief overview of the method underpinning the workshops and outcomes
3. An overview map detailing the opportunities, issues and a map detailing the social values relating to MMS
4. A list of project next steps regarding social value

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number CTR-10729).

Project Background

This project is a collaboration between the Fisheries Research and Development Corporation, Curtin University, The University of Western Australia and the West Australian Marine Science Institution to explore the socioeconomic values associated with MMS. The project has four aims:

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.

Initial findings from a literature review exploring social and economic values associated with MMS demonstrated that gaps exist within the current body of available research. These include: being discrete in nature, limited diversity of stakeholder view (e.g. focused on one or two groups only), limited specific exploration of MMS (e.g. natural reefs rather than artificial), and not being specifically applicable to a West Australian context (e.g. primarily from other states or countries). As such, using only existing literature to inform this research project would be insufficient.

In order to achieve our research aims the team has carried out online workshops with people from Perth, Exmouth, Karratha, Onslow and particular cohorts e.g. regulators, oil and gas, as well as creating and disseminating a survey for recreational fishers and divers, and determining the monetary value MMS generated by the structures and associated activities. Throughout the data collection process integration between social and economic findings will be completed to achieve a broad and well-informed picture of qualitative, semi-quantitative and quantitative aspects associated with MMS.

Brief Overview

Online Busselton Workshop, 14th July 2020

- Participant 1
- Participant 2
- Participant 3
- Participant 4

Facilitators: Fran Ackermann, Euan Harvey

Overview

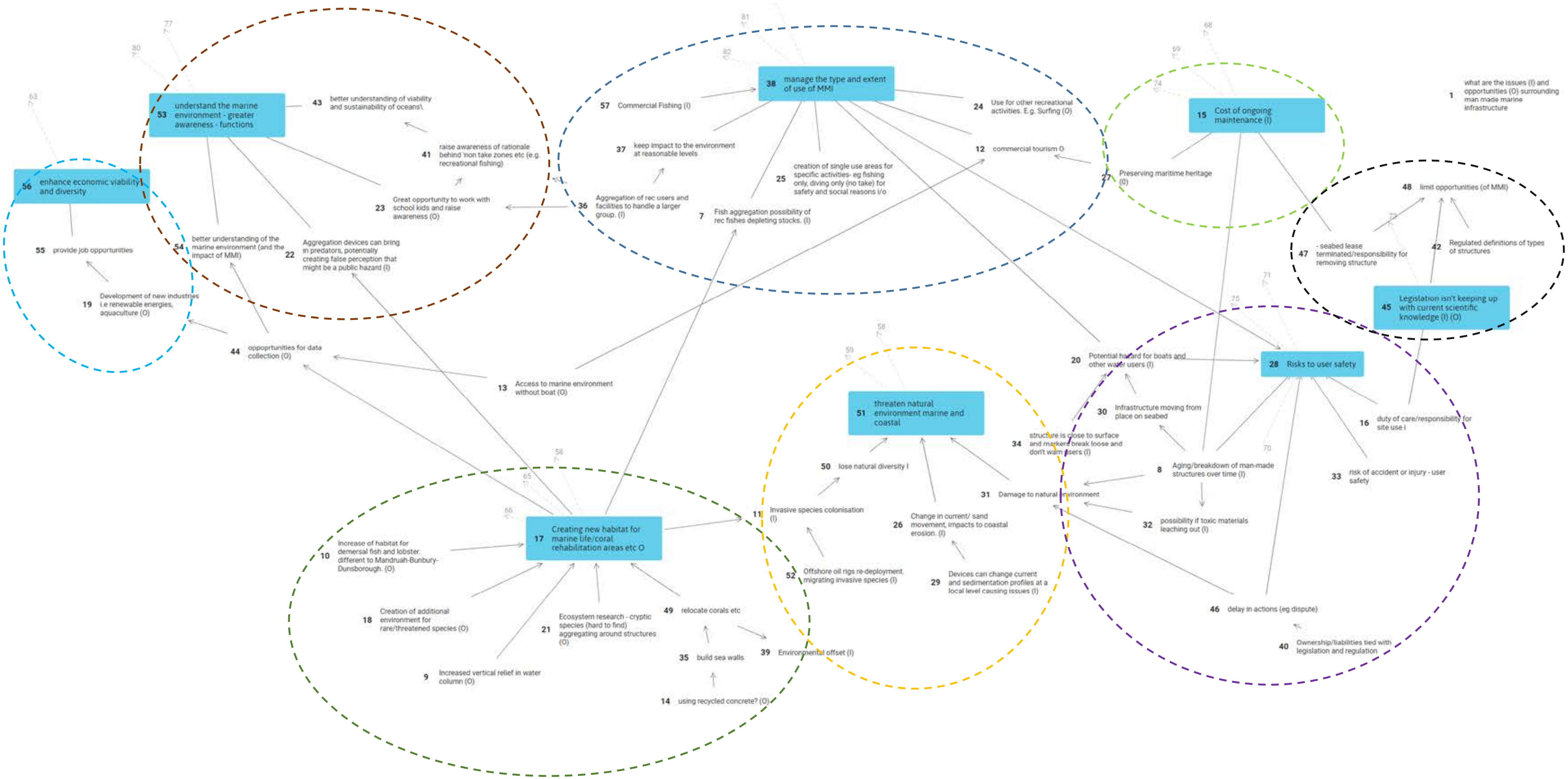
The workshop focused on “what are the issues and opportunities regarding man-made marine infrastructure?” Each participant was given the opportunity to contribute both Issues and Opportunities (denoted by ‘I’ or ‘O’) in relation to the focal question. Using a group mapping process, each participant could anonymously contribute to the focal question, seeing their ideas and the contributions of others on their screen and thus ‘piggyback’ off one another providing a rich reservoir of contributions. The surfaced material was put into rough ‘content oriented’ clusters and subsequently reviewed by the group allowing for new material to be surfaced as well as to ensure all were clear as to the meaning of the statements.

During the process of elaboration, it became clear that a number of the statements impacted others and so the process of causally linking the statements together was undertaken. This resulted in a ‘map’ of interconnected issues and opportunities helping tease out a rich picture of the statements along with their systemic properties reflecting the complexity of the topic The linked clusters were reviewed and ‘headline’ statements identified and given a different style (blue box). Each represented a specific theme. Map 1 shows the issues, opportunities and headline statements.

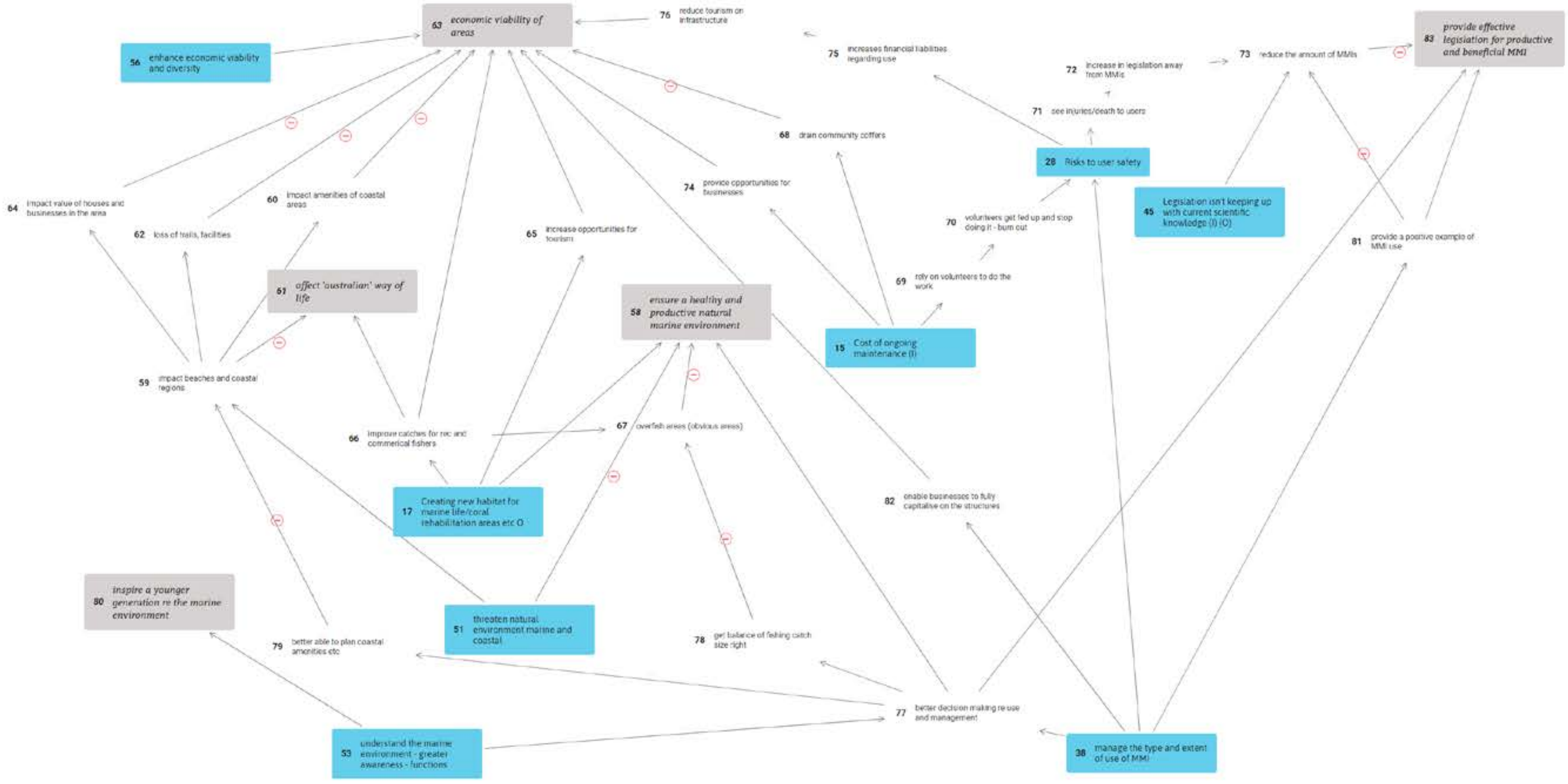
To conclude the first part of the morning session, a prioritisation process was undertaken asking the participants to rate the headline statements (see Table 1).

Results. After a brief break, the group reviewed the headline issues and explored the implications of each, i.e. what value they either supported (opportunities) or attacked (issues). Each value was identified and given a particular attribute (grey box). Map 2 showings the headline issues, values and interconnecting material.

Map 1. Issues and opportunities identified in the Busselton



Map 2. values identified in the Busselton



Note: 'Grey boxes' refer to social values. A minus sign on the arrowhead reflects the opposite.

Reflections from the Busselton Workshop

Reviewing the Issues and Opportunities

- Number of issues = 26, number of opportunities = 21, 3 of both issues and opportunities – revealing that participants were aware of a range of considerations and took a balanced perspective
- The themes are not mutually exclusive – they share statements – representing the systemic nature inherent in considering MMS
- In many instances themes comprise both Issues and Opportunities demonstrating potential dilemmas.
- Some themes are more developed than others – for example, the theme 38 *manage the type and extent of use of MMI* had 9 statements whereas 19 *cost of ongoing maintenance* and 56 *enhance economic variability and diversity* were less developed.
- There are eight themes as noted on the map (as reflected by the dotted ellipses)

Reviewing the values

- There emerged 5 values addressing economic, regulatory, marine health, awareness and culture.
- The theme '*manage the type and extend of use of MMI*' addressed 4 of the 5 values making it quite significant

Table 1. Rating of importance of issues and opportunities from the perspective of recreational fishing

Theme	Average Rating (out of 10)	Degree of Consensus
38. Manage the type and extent of the use of MMI	8.80	1.10
28. Risk to users safety	7.00	2.10
17. Creating new habitat for more life/coral rehabilitation areas	6.50	1.50
51. Threaten natural environment (marine and costal)	6.50	2.50
45. Legislation isn't keeping up with current scientific knowledge	6.00	1.90
15. Cost of ongoing maintenance	5.80	2.90
53. Understand the marine environment – greater awareness functions	5.50	2.70
56. Enhance economic viability and diversity	5.00	1.40

Note: The lower the number the greater the degree of consensus. As such, statement 38 had the highest average and the greatest degree of consensus.

Next Steps

1. Conduct further ‘workshops’ with additional stakeholder groups for example; commercial fishing
2. Integrate, compare and contrast findings from all workshops along with material from a workshop undertaken with the steering committee
3. Develop a causal model depicting social values and man-made aquatic infrastructure within the West Australian context
4. Develop semi quantitative models including Multi-Criteria Decision Models to further assess and understand social value
5. Integrate workshop findings with findings from other parts of the research project (literature review, survey data, economic data etc.)

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

Commercial Fishing Workshop Feedback Report

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Executive Summary

As part of the research project focusing on "Enhancing the Understanding of the Value Provided to Fisheries by Man-Made Aquatic Structures" an online workshop was held on the 21st July with representatives from Commercial Fishing. This workshop focused on exploring the issues and opportunities regarding man-made marine structures (MMS) along with determining social values associated with the prioritised issue/opportunity themes. The workshop, facilitated by Fran Ackermann and supported by Euan Harvey and Georgie Hill, involved 7 participants and used an online computer – based system to capture, model and synthesise views. This report focuses purely on the material generated from the workshop, however, this material will be integrated with material from other online workshops and those conducted face to face, as well as with the results of a survey and various economic value assessment analyses.

This short report comprises of:

1. Project Background
2. A brief overview of the method underpinning the workshops and outcomes
3. An overview map detailing the opportunities, issues and a map detailing the social values relating to MMS
4. A list of project next steps regarding social value

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number CTR-10729).

Project Background

This project is a collaboration between the Fisheries Research and Development Corporation, Curtin University, The University of Western Australia and the West Australian Marine Science Institution to explore the socioeconomic values associated with MMS. The project has four aims:

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.

Initial findings from a literature review exploring social and economic values associated with MMS demonstrated that gaps exist within the current body of available research. These include: being discrete in nature, limited diversity of stakeholder view (e.g. focused on one or two groups only), limited specific exploration of MMS (e.g. natural reefs rather than artificial), and not being specifically applicable to a West Australian context (e.g. primarily from other states or countries). As such, using only existing literature to inform this research project would be insufficient.

In order to achieve our research aims the team has carried out online workshops with people from Perth, Exmouth, Karratha, Onslow, Busselton and particular cohorts e.g. regulators, oil and gas, recreational fishing as well as creating and disseminating a survey for recreational fishers and divers, and determining the monetary value MMS generated by the structures and associated activities. Throughout the data collection process integration between social and economic findings will be completed to achieve a broad and well-informed picture of qualitative, semi-quantitative and quantitative aspects associated with MMS.

Brief Overview

Commercial Fishing Workshop, 21st July 2020

- Participant 1
- Participant 2
- Participant 3
- Participant 4
- Participant 5
- Participant 6

Participant 7

Facilitators: Fran Ackermann, Euan Harvey

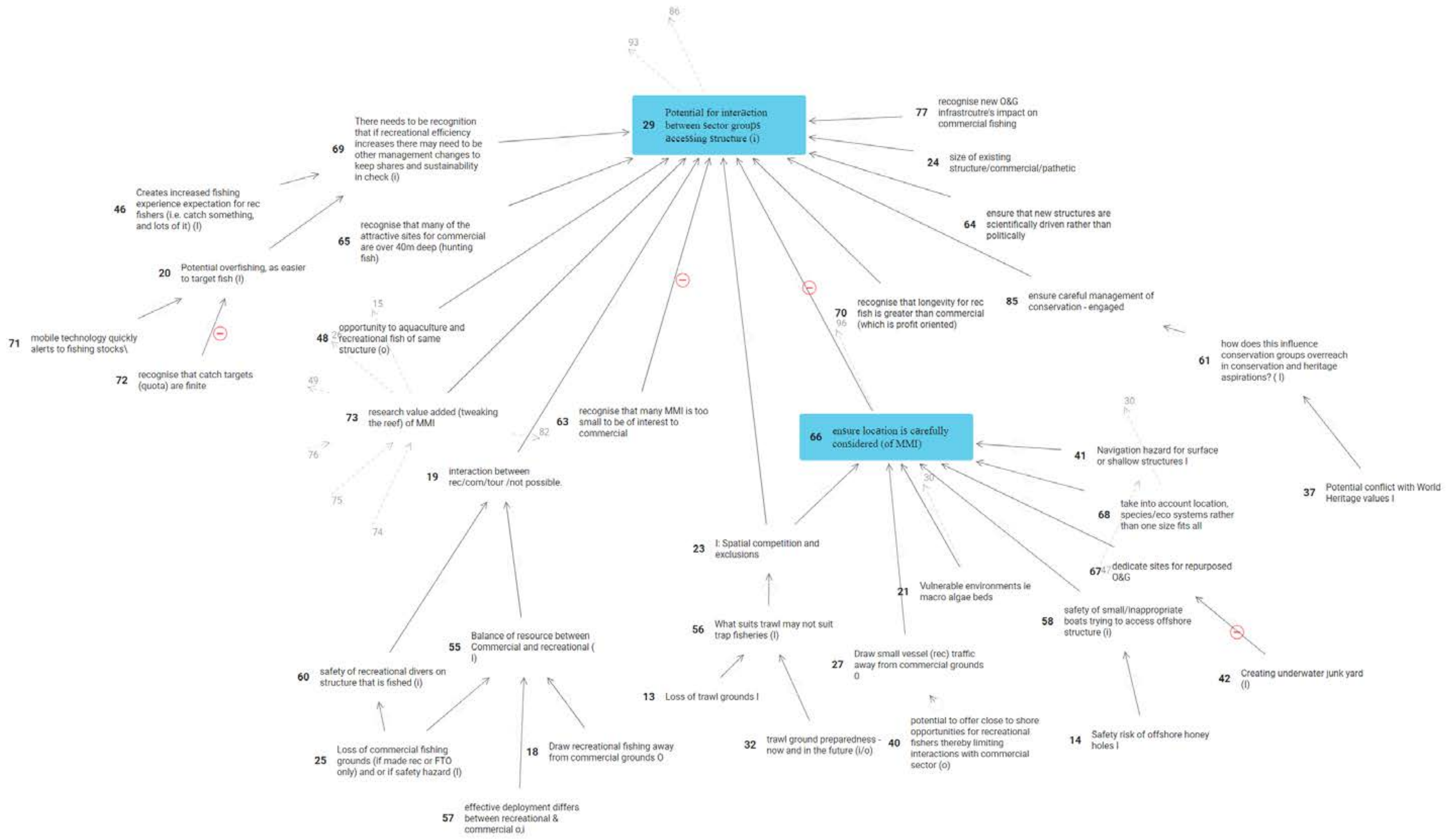
Overview

The workshop focused on “what are the issues and opportunities regarding man-made marine infrastructure?” Each participant was given the opportunity to contribute both Issues and Opportunities (denoted by ‘I’ or ‘O’) in relation to the focal question. Using a group mapping process, each participant could anonymously contribute to the focal question, seeing their ideas and the contributions of others on their screen and thus ‘piggyback’ off one another providing a rich reservoir of contributions. The surfaced material was put into rough ‘content oriented’ clusters and subsequently reviewed by the group allowing for new material to be surfaced as well as to ensure all were clear as to the meaning of the statements.

During the process of elaboration, it became clear that a number of the statements impacted others and so the process of causally linking the statements together was undertaken. This resulted in a series of ‘maps’ of interconnected issues and opportunities helping tease out a rich picture of the statements along with their systemic properties reflecting the complexity of the topic. The linked clusters were reviewed and ‘headline’ statements identified and given a different style (blue box). Each represented a specific theme. Map 1-3 shows the issues, opportunities and headline statements.

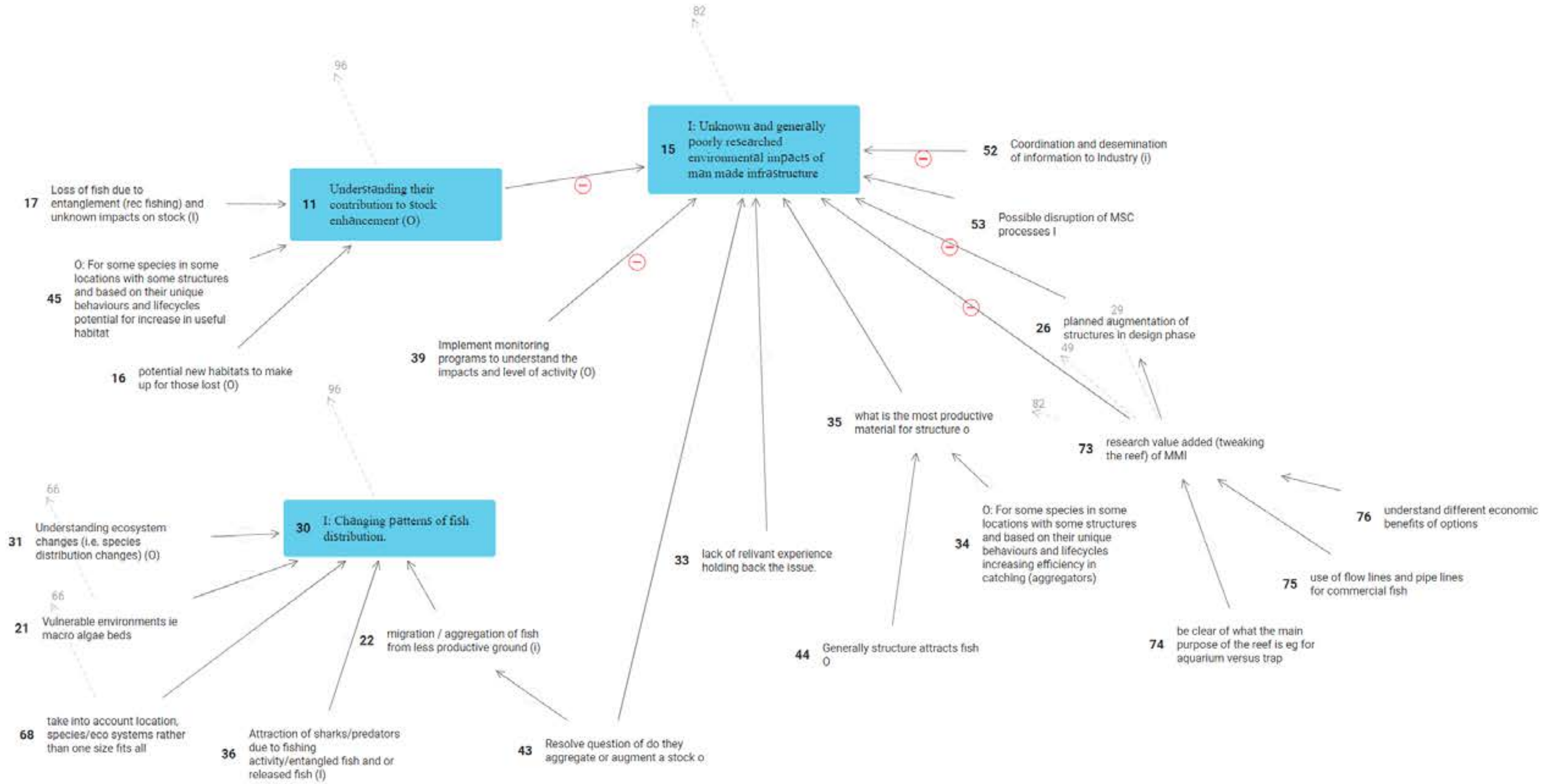
Results. After a brief break, the group reviewed the headline issues and explored the implications of each, i.e. what value they either supported (opportunities) or attacked (issues). Each value was identified and given a particular attribute (grey box). Map 4 showings the headline issues, values and interconnecting material.

Map 1. Issues and opportunities identified

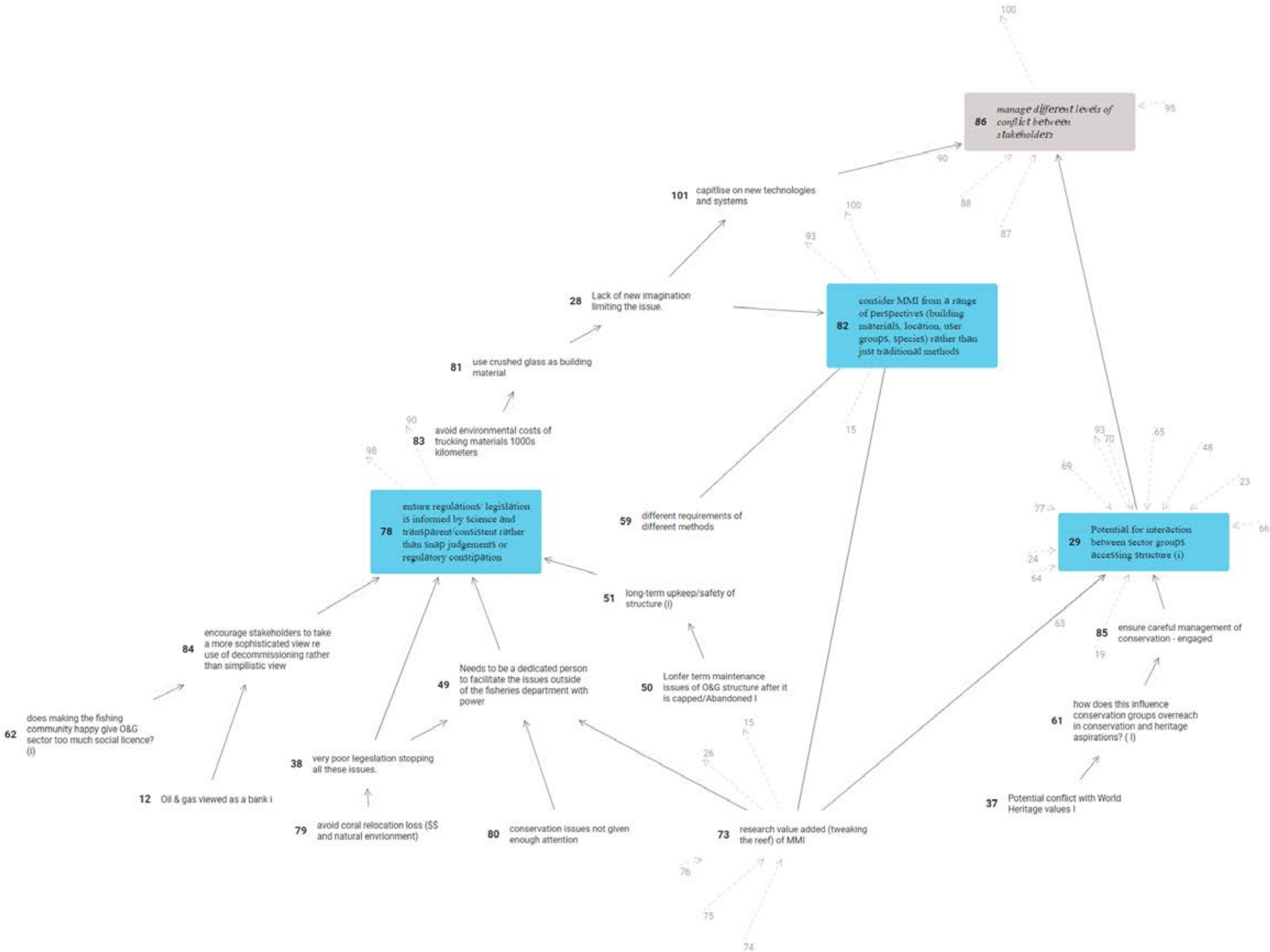


Note: 'Blue boxes' refer to headline statements. A minus sign on the arrowhead reflects a negative link

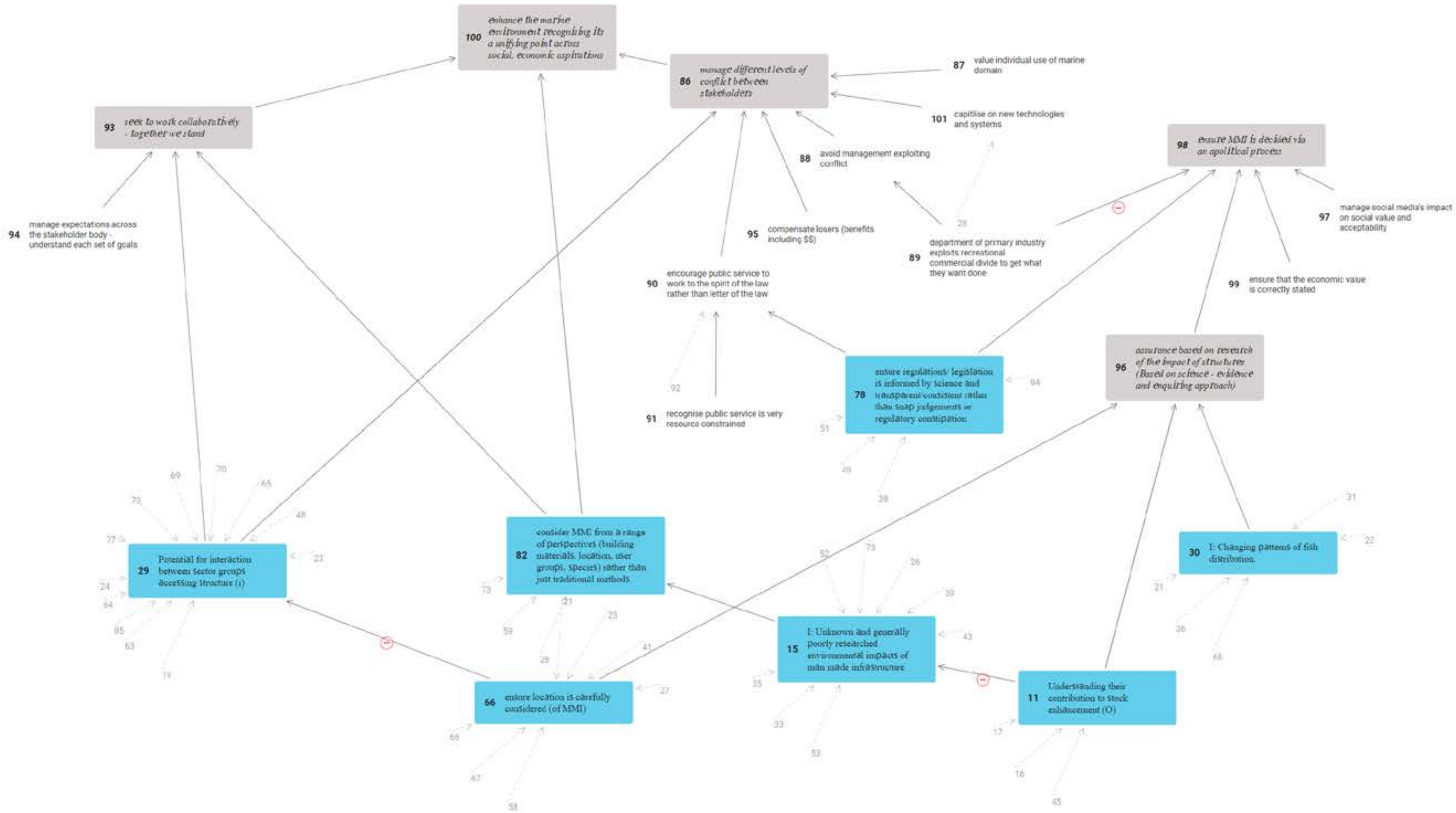
Map 2. Issues and opportunities



Map 3. Issues and opportunities



Map 4. The values



Note: 'Grey boxes' refer to social values. A minus sign on the arrowhead reflects the opposite.

Reflections from the Commercial Fishing Workshop

Reviewing the Issues and Opportunities

- The workshop surfaced 40 issues and 26 opportunities with 7 statements that were both issues and opportunities resulting in 73 statements. This suggests that there are a number of factors to consider when considering the social value of MMS and that participants were aware of a range of considerations and took a balanced perspective.
- The three emergent themes were identified revealing the areas concerning commercial fishing representatives and that these could be compared with those themes concerning other populations ensuring a comprehensive understanding. Moreover they are not mutually exclusive – they share statements – representing the importance of taking a systemic view when considering MMS. This interconnectivity is illustrated through the 'hidden' arrows (dotted arrows with numbers at the head) showing the links between the three theme based maps. Systemicity not only is important when considering actions for today but also for the long term.
- The themes comprise both Issues and Opportunities demonstrating potential dilemmas (where an action can have both a positive and negative effect on the outcome) and therefore careful thought was required.
- Some themes are more elaborated than others – for example, the theme *29 potential for interaction between sector groups* had 13 statements related to it, whereas 19 *cost of ongoing maintenance* and 56 *enhance economic variability and diversity* were less developed.

Reviewing the values

- There emerged 5 values
    - Three (60%) of the values related to 'users'. This emphasis reflected the challenges in balancing potentially competing interests, importance of understanding the different aspirations and expectations to enable collaboration and leveraging new approaches/technologies.
    - The other two values dealt with regulation (being apolitical) and the need for science based research (which would assist with the apolitical process.

General observations

The workshop highlighted the importance of considering MMI in the context of users and their aspirations for the structure alongside the different economic benefits accrued. As such research into the value of options was important as well as disseminating that information.

It was also noted that considering cohorts as a single entity such as ‘commercial fishers’ was too high a level of aggregation as there was consider differences in objectives/impact of trawling, trap, aquarium etc.

In addition, thinking creatively, adopting new technologies and taking into account the location/conditions of the proposed location were seen as key factors.

Next Steps

1. Conduct further 'workshops' with additional stakeholder groups for example; commercial fishing
2. Integrate, compare and contrast findings from all workshops along with material from a workshop undertaken with the steering committee
3. Develop a causal model depicting social values and man-made aquatic infrastructure within the West Australian context
4. Develop semi quantitative models including Multi-Criteria Decision Models to further assess and understand social value
5. Integrate workshop findings with findings from other parts of the research project (literature review, survey data, economic data etc.)

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

NGO Conservation Workshop Feedback Report

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Executive Summary

As part of the research project focusing on "Enhancing the Understanding of the Value Provided to Fisheries by Man-Made Aquatic Structures" an online workshop was held on the 21st July with representatives from NGO Conversation. This workshop focused on exploring the issues and opportunities regarding man-made marine structures (MMS) along with determining social values associated with the prioritised issue/opportunity themes. The workshop, facilitated by Fran Ackermann and supported by Luke Twomey and Carmen Elrick-Barr, involved 6 participants and used an online computer – based system to capture, model and synthesise views. This report focuses purely on the material generated from the workshop, however, this material will be integrated with material from other online workshops and those conducted face to face, as well as with the results of a survey and various economic value assessment analyses.

This short report comprises of:

1. Project Background
2. A brief overview of the method underpinning the workshops and outcomes
3. An overview map detailing the opportunities, issues and a map detailing the social values relating to MMS
4. A list of project next steps regarding social value

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number CTR-10729).

Project Background

This project is a collaboration between the Fisheries Research and Development Corporation, Curtin University, The University of Western Australia and the West Australian Marine Science Institution to explore the socioeconomic values associated with MMS. The project has four aims:

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.

Initial findings from a literature review exploring social and economic values associated with MMS demonstrated that gaps exist within the current body of available research. These include: being discrete in nature, limited diversity of stakeholder view (e.g. focused on one or two groups only), limited specific exploration of MMS (e.g. natural reefs rather than artificial), and not being specifically applicable to a West Australian context (e.g. primarily from other states or countries). As such, using only existing literature to inform this research project would be insufficient.

In order to achieve our research aims the team has carried out online workshops with people from Perth, Exmouth, Karratha, Onslow, Busselton and particular cohorts e.g. regulators, oil and gas, recreational fishing as well as creating and disseminating a survey for recreational fishers and divers, and determining the monetary value MMS generated by the structures and associated activities. Throughout the data collection process integration between social and economic findings will be completed to achieve a broad and well-informed picture of qualitative, semi-quantitative and quantitative aspects associated with MMS.

Brief Overview

NGO Conservation workshop, 12th August 2020

- Participant 1
- Participant 2
- Participant 3
- Participant 4
- Participant 5
- Participant 6

Facilitators: Fran Ackermann, Carmen Elrick-Barr

Overview

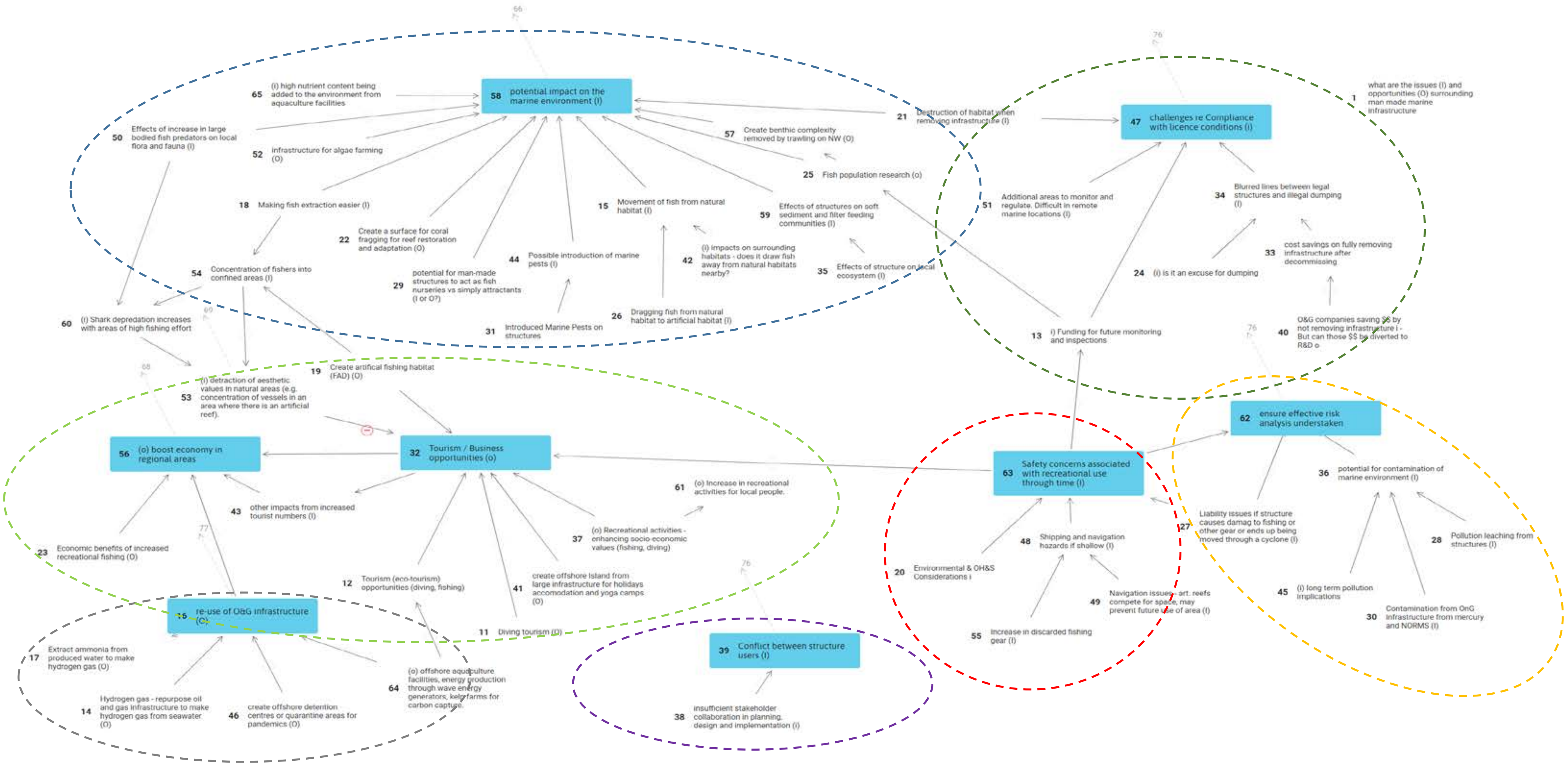
The workshop focused on “what are the issues and opportunities regarding man-made marine infrastructure?” Each participant was given the opportunity to contribute both Issues and Opportunities (denoted by ‘I’ or ‘O’) in relation to the focal question. Using a group mapping process, each participant could anonymously contribute to the focal question, seeing their ideas and the contributions of others on their screen and thus ‘piggyback’ off one another providing a rich reservoir of contributions. The surfaced material was put into rough ‘content oriented’ clusters and subsequently reviewed by the group allowing for new material to be surfaced as well as to ensure all were clear as to the meaning of the statements.

During the process of elaboration, it became clear that a number of the statements impacted others and so the process of causally linking the statements together was undertaken. This resulted in a series of ‘maps’ of interconnected issues and opportunities helping tease out a rich picture of the statements along with their systemic properties reflecting the complexity of the topic. The linked clusters were reviewed and ‘headline’ statements identified and given a different style (blue box). Each represented a specific theme. Map 1 shows the issues, opportunities and headline statements. The group prioritised the headlines according to their level of importance in relation to social value

Results. After a brief break, the group reviewed the headline issues and explored the implications of each, i.e. what value they either supported (opportunities) or attacked (issues). Each value was identified and given a particular attribute (grey box). Map 4 showings the headline issues, values and interconnecting material.

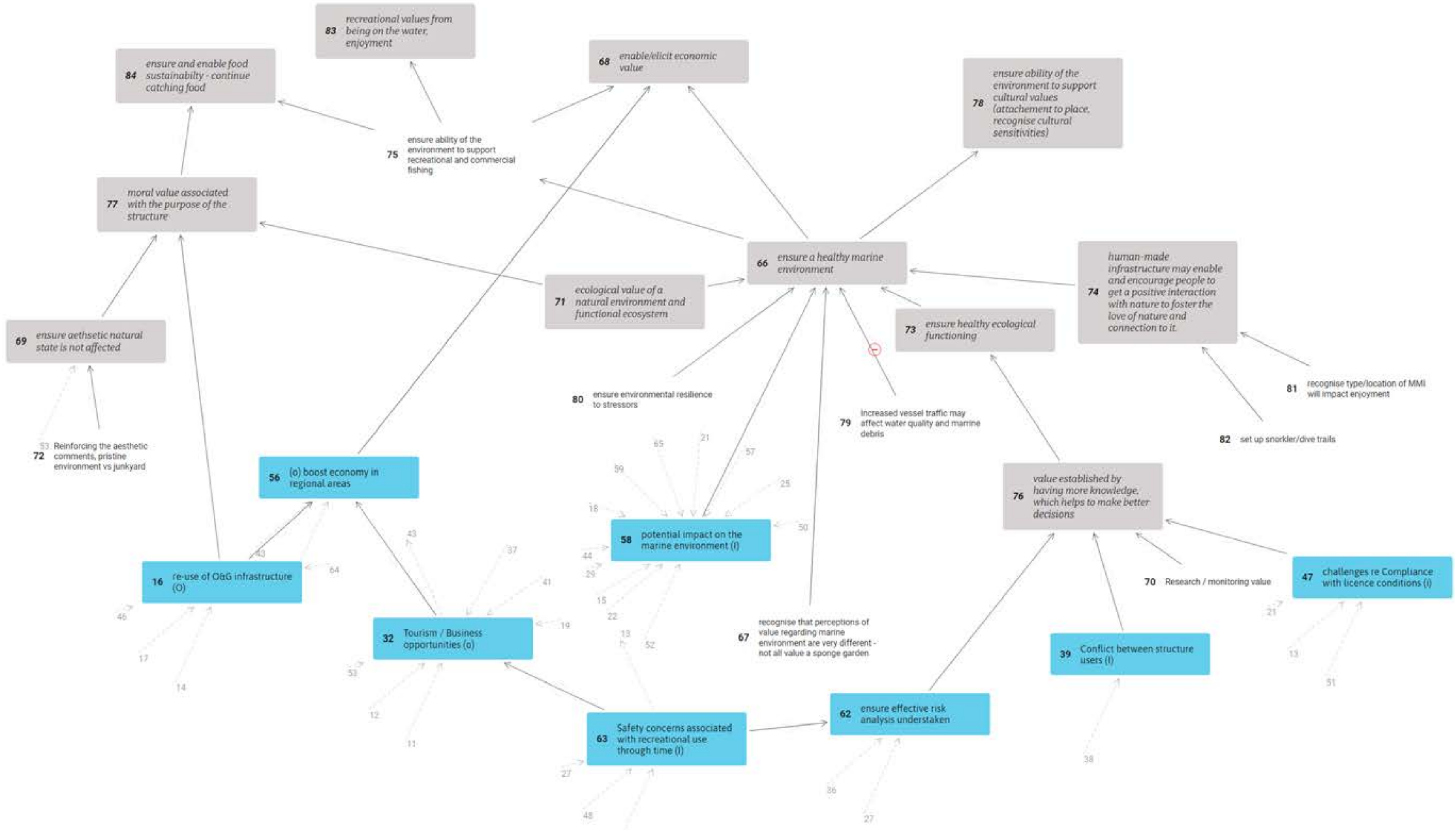
Maps of Issues, Opportunities and Social Values Associated with Man-Made Marine Structures

Map 1. Issues and opportunities



Note: ‘Blue boxes’ refer to headline statements. A minus sign on the arrowhead reflects a negative link

Map 2. The values



Note: 'Grey boxes' refer to social values. A minus sign on the arrowhead reflects the opposite.

Reflections from the NGO Conservation Workshop

Reviewing the Issues and Opportunities

- The workshop surfaced 30 issues and 21 opportunities with 1 statement that were both issues and opportunities resulting in 52 statements with potentially a concerned outlook (i.e. more issues than opportunities). As such the workshop revealed that there are a number of factors to consider when considering the social value of MMS and that participants took a wide ranging perspective.
- The largest of the themes (in terms of supporting material) was 58 *potential impact on the marine environment* – not surprisingly given the participants were from conversation NGOs. The second largest theme focused on 32 *Tourism/business opportunities* – which was influenced by material supporting the *marine impact* theme as well as the safety theme (thus reflecting the need to take a systemic approach). The smallest theme focused on *potential conflict between stakeholder/user group*s – containing only 2 statements and not being linked to any of the other themes (potentially due to time constraints).
- The majority of the themes comprise both Issues and Opportunities demonstrating potential dilemmas (i.e. where an action can have both a positive and negative effect on the outcome) and therefore careful thought was required when considering any action.

Reviewing the priorities

Each of the theme headlines was rated according to its importance towards social and economic value.

- The headline that had the highest average (i.e. was seen as the most important in relation to social value) was that of *potential impact on the marine environment* (8.7/10) however the degree of consensus/standard deviation (2.3) reflected that whilst the majority saw it as the most important not all did. The second 'most important' headline was *tourism/business opportunities* (8.3/10) with a higher degree of consensus (0.94). The third most important was *boost the economy* (8/10) with high degree of consensus (1.0). *Tourism/business opportunities* directly linked to *boost the economy* and *impact on marine environment* indirectly (through intermediary issues/opportunities) impacted *tourism/business opportunities* suggesting they were integrated and would benefit from being seen as a 'package'. There was then a considerable gap to the next most important suggesting that these three were seen as the key themes. Moreover they either directly, or through intermediary statements connected to one another.

Table 1. Rating of importance of issues and opportunities from the perspective of NGO Conservation participants

Theme	Average Rating (out of 10)	Degree of Consensus
58. potential impact on the marine environment (8)	8.70	2.60
32. tourism/business opportunities (12)	8.30	0.97
56. boost economcy in regional areas (20)	8.00	1.00
16. re-use of O&G infrastrucutre (19)	6.20	2.50
62. ensure effective risk analysis undertaken (29)	5.50	2.40
63. safety concerns associated with recreational use through time (13)	5.20	2.50
47. Challenges re compliance with licensing conditions (6)	4.30	1.10
39. Conflict between structure users (5)	3.00	1.30

Note: The lower the number the greater the degree of consensus. As such Statement 58 had the highest average. 32 received the greatest degree of consensus.

Reviewing the values

- There emerged 9[1] values
  - Whilst social value was viewed as important, the discussion and resultant material reflected the need to take a very wide consideration of value associated with MMS – going beyond social and economic values.
  - The values reflected the breadth of stakeholders ranging from indigenous communities, to commercial fishers, from those taking decisions to enjoyment by recreational fishers.
  - The most central value related to 'ensuring a healthy marine environment with links (direct or via other material) to all bar two of the values

General observations

The focus group provided valuable material to the study, not only reinforcing a number of the themes and values (identified from other focus group workshops) but in addition generating new values to be considered. The process enabled both the capture of material (issues, opportunities and values) but also the structuring of the material and development of prioritised themes.

[1] Statements 66, 71 and 73 were closely connected and deemed one value

Next Steps

1. Integrate, compare and contrast findings from all workshops along with material from a workshop undertaken with the steering committee
2. Develop a causal model depicting social values and man-made aquatic infrastructure within the West Australian context
3. Develop semi quantitative models including Multi-Criteria Decision Models to further assess and understand social value
4. Integrate workshop findings with findings from other parts of the research project (literature review, survey data, economic data etc.)

Appendix 9 Economic impact of removing Echo Yodel on commercial fishing

Paul McLeod & Michael Burton

This appendix is part of the final report for:

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

Euan S. Harvey, Fran Ackermann, Michael Burton, Julian Clifton, Carmen Elrick-Barr, Johanna Zimmerhackel, Georgina Hill, Stephen J Newman, Jenny Shaw, Mark Pagano, Paul McLeod, Dianne McLean, Julian Partridge

24th August 2021

FRDC Project No 2018-053

Economic Impact of Removing Echo Yodel on Commercial Fishing

Prepared for the FRDC Project: Enhancing the Understanding of the Value Provided to Fisheries by Man-Made Aquatic Structures

Report Prepared By:

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1 INTRODUCTION

Large-scale subsea infrastructure is a feature of the offshore oil and gas industry. One challenge for the industry is the management of this infrastructure when it reaches the end of its production life. It requires decommissioning. Options for decommissioning include in situ abandonment after required treatment, removal, and relocation, for example, to form artificial reefs, and complete removal.

While it would seem logical that to require removal of these artificial structures, the decision is not so simple. This is because, in situ, they have over time had arrange of impacts on the marine environment. Removal will likewise have potential and complex effects.

This paper looks at one aspect of this process—the potential impact on commercial fishers who operate on and around the subsea structure.

The structure of interest for this report is Echo Yodel.

Echo Yodel is a Woodside energy pipeline located 137 km north-west of Dampier in Western Australia. Woodside is the operator of the Echo Yodel and Capella-1 infrastructure on behalf of the North West Shelf Project participants. The participants are Woodside Energy Ltd, BHP Billiton Petroleum (North West Shelf) Pty Ltd, BP Developments Australia Pty Ltd, Chevron Australia Pty Ltd, Japan Australia LNG (MIMI) Pty Ltd and Shell Australia Pty Ltd. (Woodside, 2019)

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 and Yodel-4) but leaves in-situ the Echo Yodel infrastructure. This includes the pipeline, the umbilical and subsea wellheads.

The final decision on the future management of Echo Yodel is still being considered.

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 have identified a range of commercially relevant species that have established on the infrastructure. (Bond et al., 2018)

Commercial fishers do fish in the area. They are participants in the Pilbara Trap fishery, which harvests a range of demersal species.

To assess the impact on these fishers from removal of the structure, we need an appropriate framework. The next section considers a generic framework for assessing the impact on fishers of subsea infrastructure removal. This establishes the principles and data requirements needed to develop estimates of economic consequences for any case.

1.1 ECONOMIC CONSEQUENCES OF REMOVING SUBSEA INFRASTRUCTURE – THEORETICAL CONSIDERATIONS

For this exercise we assume a managed fishery with a management regime that can match harvest levels with known biomass to ensure sustainable harvest.

Subsea structures potentially enhance the fishing outcomes for commercial fishers in several ways.

Structures act as potential aggregators of fish species of commercial interest. Aggregation increases fish density and allows fishers to harvest more efficiently. Their catch per unit of effort will be higher on the structure compared to locations away from the structure. Aggregation without production is not a reason to revise the harvest strategy. The benefits to fishers arise because with the denser biomass and higher catch per unit of effort, operating costs are reduced and, all other things equal, operating surplus increases. With unchanged total catch revenue will not change.

Beyond aggregation structures may increase production. Where this happens, there is enhanced density on the structure but also an enhanced biomass overall. Fishing on the structure will have enhanced catch per unit of effort as above, but the enhanced production allows a potential revision of the harvest strategy with an increased harvest. There is a potential revenue increase from the increased harvest and a cost reduction from the increase in catch per unit of effort.

Harvest strategies do not restrict fishers to the area on and in the near vicinity of the subsea structure. They have available a much wider range of locations. Therefore, the subsea structure location is best interpreted as just one area of operation for which there are available alternatives or substitutes. Given the impact of the subsea structure on the ecosystem in encouraging aggregation and perhaps production, it likely is one of the more attractive locations to fish. Hence the expectation is that it will feature in the fisher’s harvest planning.

In practice, the relative attractiveness of the subsea infrastructure as a fishing location, will be reflected in fisher behaviour. Fishers will schedule the location into their fishing programme if utilising it improves their overall economic performance. This is indicative that the location offers improved catchability, compared to at least some alternative locations they could fish.

The idea of substitutes in fishing locations goes to the question of spatial heterogeneity in the marine environments and species population characteristics in the ocean areas where the fishers can operate.

Two broad simplifying assumptions are useful. These are:

- Spatial homogeneity of environmental conditions, and stock distribution.
- Spatial heterogeneity of environment conditions, population characteristics and stock distribution.

1.2 A SIMPLE MODEL BASED ON HOMOGENEITY

Absent the subsea structure, the permitted fishing area has spatial homogeneity. The installation of the structure creates a subsea environment different from that which had prevailed homogeneously before. It has favourable fishing attributes – higher density and catchability, higher catch per unit of effort and lower unit costs.

Figure 1 illustrates this case.

The subsea structure is in an otherwise homogeneous fishing area. The homogeneous area average fishing cost is ACopen per unit of catch. The subsea area offers economic advantages with the lower average fishing costs ACsubsea.

The allowed or managed harvest is H. Fishers plan to catch Hsubsea in the subsea area and the balance H-Hsubsea across the wider area.

The shaded area Ss (area abcd) is the surplus being earned from the subsea area harvest. Area So is the surplus being earned from the open area harvest.

The lower average cost per unit of catch in the subsea area arises from the marine environment created on the subsea structure with improved density and catchability and an increase in availability of commercial species.

The longer the structure remains in place, the more changed is the associated marine environment.

With removal of the subsea structure, the marine environment is potentially changed back to a state closer to the original state that existed before the structure was installed.

This will take some time. For exposition purposes, assume that the new ecosystem equilibrium approximates the original conditions. In this simple model, this restores the average harvest cost back to the open area level. The entire catch has the unit average cost ACopen. For this straightforward case, the loss to the commercial fishers depends on the difference between the average harvest costs. This leads to an estimated loss of abef. The harvest that was or is still caught in the subsea area is now caught at ACopen and earns the surplus efcd. With the structure in place this harvest was caught at the lower unit cost ACsubsea.

The loss or surplus is efcd.

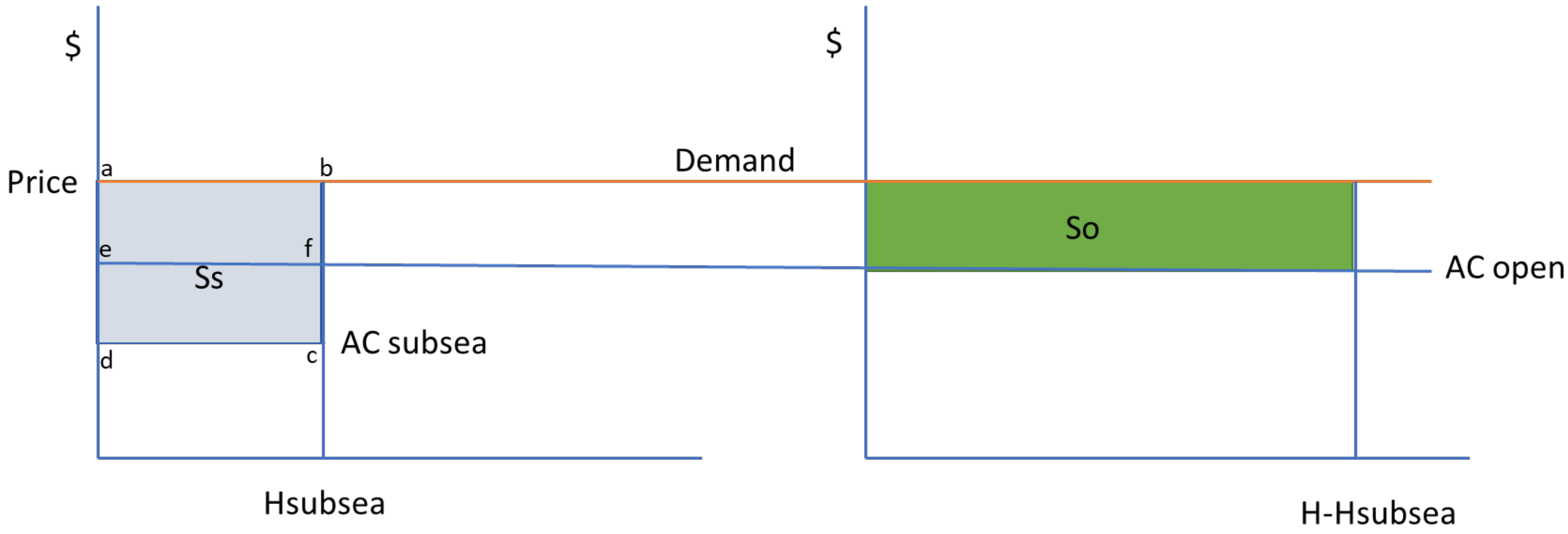
The difference in cost depends on catchability and catch per unit effort in the subsea area compared to the substitute area, in this case, the wider ocean fishing area.

Enhancements could be added to this simple model. The subsea area ecosystem may not revert simply to the previous state and may still offer some residual fishing advantages. Here, the surplus loss is smaller than that represented by the diagram.

Depending on the significance of the subsea area in their overall operations, its removal may cause fishers to recalibrate their fishing strategies when they revert to fishing optimally from the wider area. This might reduce the harvesting cost in the open area, ACopen. Again, the consequent loss of surplus would be smaller.

While these enhancements are potentially interesting, they do not change the basic conclusion. If the subsea area has become a preferred fishing location, its removal will increase overall fishing costs and reduce surpluses earned. The loss depends on the difference in catchability, catch per unit of effort and cost per unit of catch between the two areas.

Figure 1: Two Zone Model Based on Spatial Homogeneity Without Subsea Structure



1.3 A SIMPLE MODEL BASED ON HETEROGENEITY

One way to consider heterogeneity is to divide extensive fishing grounds with variability in environmental conditions, abundance heterogeneity, and variable growth and mortality patterns into smaller sub areas that can be considered independent units. Each subarea is then assumed homogeneous within the subarea.(Seijo, Defeo, & Salas, 1998) Catchability and fishing costs will vary between sub areas.

Taking this approach, optimal allocation of fishing effort spatially across the subareas would require the surplus earned in each area (Price-Marginal Cost) to be equal at the margin. This optimizes economic performance (maximizes earned surpluses) allowing for differential harvesting costs.

Absent the subsea structure, with heterogeneity, the permitted fishing area consists of different subareas.

The subsea structure is located within one of the subareas. The structure creates a subsea environment different from that which prevailed previously in that subarea. Compared to the pre-structure situation, the subarea now has more favourable fishing attributes – higher density and catchability, higher catch per unit of effort and lower unit costs.

As with the previous model, the key result is the difference that the subsea structure and associated environment make to the fishers' cost of fishing and economic returns.

However, unlike the previous model, in the heterogeneous case, the outcome depends on the relative attractiveness of the subarea containing the structure for commercial fishing.

The structure area may be in a sub area that was previously not fished because its attributes were not conducive compared to other areas. In this case, its enhanced performance causes it to be fished whereas previously it was not. Fishers rearrange the spatial fishing activity to incorporate the new subarea.

Alternatively, the subarea might be an area that was fished previously because it was commercially attractive even without the structure, but the new structure has enhanced this attractiveness. In this case, its relative attractiveness improves and its ranking within the locations to fish increases. It is now higher in the order of priority, ceteris paribus.

Figure 2 illustrates this case.

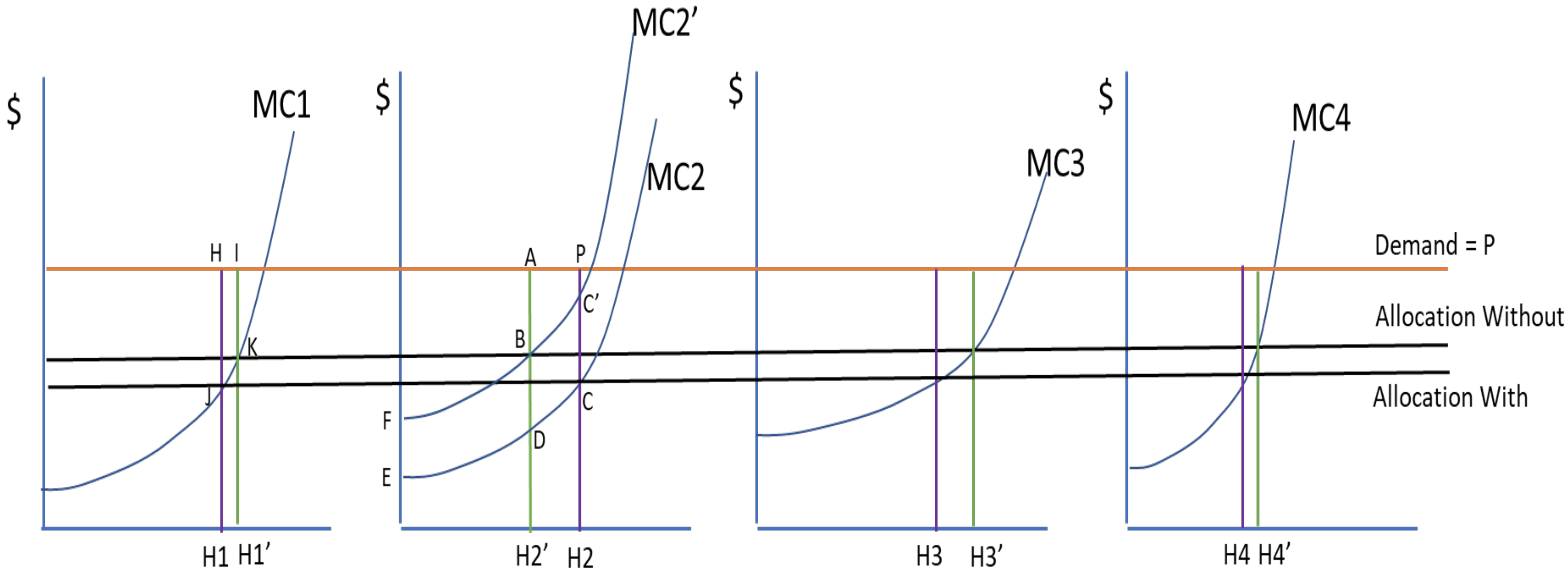
There are four subareas with marginal costs of harvest MC1 through MC4. Market price is indicated by the demand curve and is the same for harvest from each area. The subsea structure is in area 2 and has lowered the marginal cost of harvest to MC2. If effort could be pursued without limit, fishers could expand until P=MC in each area. However, as in the first model, we assume a harvest strategy which restricts the total catch. This being the case, as explained above, fishers allocate effort to make the marginal surplus (Price -Marginal Cost or P-MC) the same in each area.

With the subsea structure in place, the marginal cost in area 2 is lowered to MC2. Allocation is optimal along the "Allocation with" line with harvests of H1, H2, H3 and H4. The structure has attracted effort to area 2. The surplus is PC in area 2 and is the same for all areas.

When the structure is removed, and the environment returns to something like the previous condition, the harvest costs in area 2 increase to MC2'. Immediately the marginal returns in area 2 are reduced and are below the marginal returns in areas 1, 3, and 4. Marginal returns fall to PC' in area 2. Fishers reallocate effort away from area 2 toward the other areas where the marginal returns are now higher than in area 2. The process finds a new equilibrium when the marginal returns are equalized. This occurs at harvests H1', H2', H3' and H4'. The marginal returns are lower. In area 2, the reduction in harvest incurs losses equal to area ADCP. On the remaining harvest H2', costs are now higher with a loss equal to EFBD. Output is expanded in each other area with some surplus gain. In area 1 this is HIJK. There is a similar gain in areas 3 and 4. Therefore the net effect is the difference between the loss of surplus in area 2 and the gains in areas 1, 3, and 4. With the same target harvest there will be net loss, but this shows that its magnitude will depend on how significant the harvest cost difference is with and without the structure and the closeness of area 1, 3 and 4 as substitutes for area 2.

Although modelling spatial heterogeneity has a long history and its importance is generally accepted, models incorporating heterogeneity are data intensive and have proved difficult to calibrate. (Jardim et al., 2018).

Figure 2 Two Zone Model Based on Spatial Heterogeneity Without Subsea Structure



2 ECHO YODEL DECOMMISSIONING

2.1 PILBARA TRAP FISHERY

The Echo Yodel pipeline is within the area fished by fishers in the Pilbara Trap Managed Fishery. This managed fishery is within the North Coast Bioregion.

There are 15 different State-managed commercial fisheries operating within the North Coast Bioregion (Gaughan & Santoro, 2020). The main commercial fisheries in the area harvest tropical finfish. High-value emperors, snappers and cods that are the focus of the Pilbara trap, line and trawl fisheries and the Northern Demersal Scalefish Fishery.

The typical catch across these fisheries is in the order of 3,000-4000 tonnes annually. Estimated combined annual value is $10 -$20 million (Gaughan & Santoro, 2020). The implied average price range is$3 - $5 per kg. At this value, they are the most valuable finfish fisheries in Western Australia.

Within the Inshore Demersal region, there are four managed fisheries, the Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF); the Pilbara Trap Managed Fishery (PTMF); the Pilbara Line Fishery (PLF); and the Northern Demersal Scalefish Managed Fishery (NDSF).

The major demersal scalefish catches in the Pilbara come from the three managed fisheries - the Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF); the Pilbara Trap Managed Fishery (PTMF); the Pilbara Line Fishery (PLF). Management of these fisheries is primarily through input controls. There is a total allowable effort (TAE) allocation system via individually transferable effort (ITE) allocations. The management regime within the current harvest strategy defines an acceptable catch range for each fishery (DPIRD, 2017).

The accepted catch ranges are 94-1,416 tonnes for the Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF), 241-537 tonnes for the Pilbara Trap Managed Fishery (PTMF) and 36-127 tonnes for the Pilbara Line Fishery (PLF).

The Pilbara Fish Trawl Fishery demersal scalefish catch primarily harvests lower-valued species such as bluespotted emperor and threadfin bream. Gross value is estimated to be $5-10 million The Pilbara Trap and Pilbara Lines fisheries harvest more valuable species such as red emperor and goldband snapper. The value of the demersal scalefish catch from these sectors is around $1-5 million.

The Pilbara Fish Trawl Fishery employs around 10 fishers on 2 vessels. The Pilbara Trap Managed Fishery employment is around 8 fishers on 3 vessels. The Pilbara Line Fishery employs around 15 fishers on 5 vessels (Gaughan & Santoro, 2020).

Over recent years, the trawl catch averages around 1,200 tonnes annually, while the annual caches by the trap fishery and the line fishery are smaller at around 400 tonnes and within the range 40 to 260 tonnes, respectively.

The demersal fisheries in the North Coast Bioregion are not large in absolute terms, although they are relatively important in the spectrum of commercial fishing in Western Australia.

The estimated 2018 the catch and gross values are shown in Table 1.

Table 1: Catch and Gross Catch Values in Pilbara Fisheries

Fishery	Catch	Value
Pilbara Trawl	1,996	$5-10 million
Pilbara Trap	563	$1-5 million
Pilbara Line	93	$1-5 million

Source: (Gaughan & Santoro, 2020)

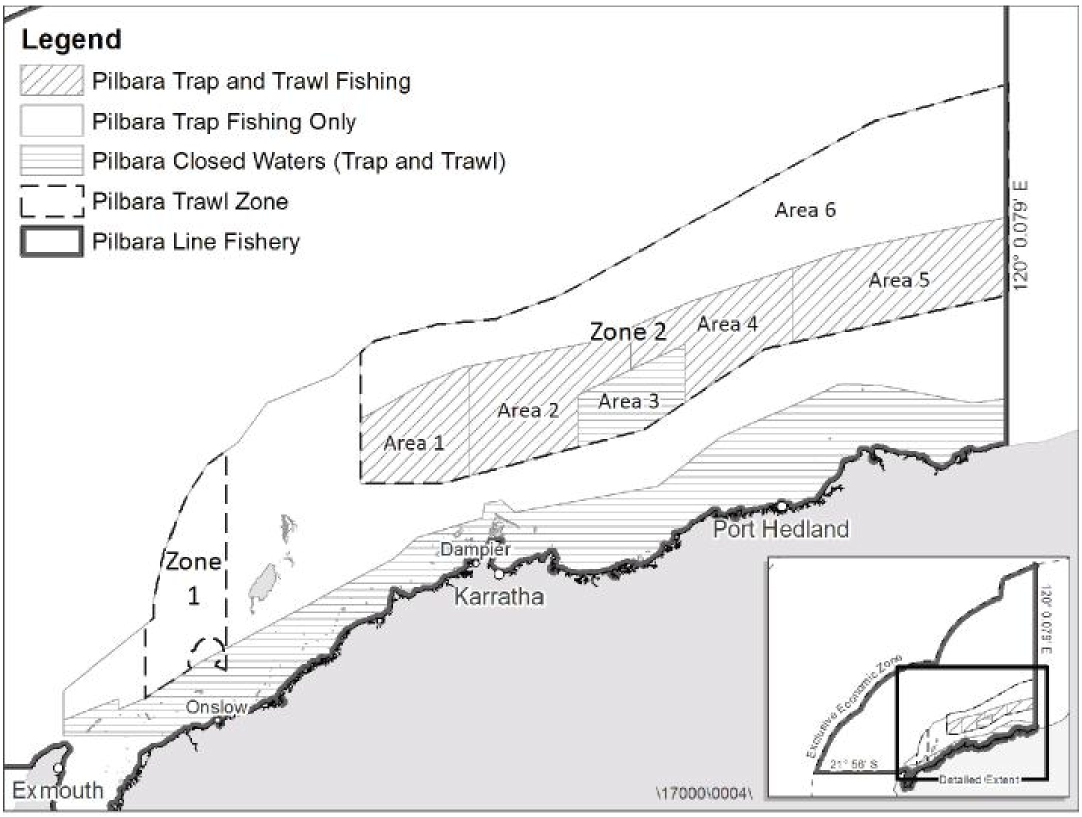
The Echo Yodel pipeline is in the trap fishery area.

In summary, in 2018 the trap fishery harvested 563 tonnes which was slightly outside of the acceptable harvest range. However, average catches over recent years have been around 400 tonnes.

At $5 per kg, harvest value is around $2.8 million in 2018 and $2 million on average. It directly employs around 8 fishers on three vessels. There are 6 licences permitted to operate in the fishery. Available information indicates that two owners hold all 6 licences.

The allowed fishing area for the trap fishery is shown in Figure 3.

Figure 3: Fishing Zones for the Pilbara Fisheries



This area is extensive and the area around Echo Yodel is a relatively small area within the larger area of operation.

2.2 COMMERCIAL VALUE OF ECHO YODEL

The limited data available means that applying the heterogeneous model as outlined above is not feasible for the Pilbara Trap Fishery and the Echo Yodel pipeline. Hence, we will work with the simpler homogeneous model. However, even for this model, data availability is a constraint.

There is evidence that the marine environment along the pipeline has become more favourable as a fish habitat since the pipeline was installed 18 years ago. Recent surveys reveal an increase in fish stocks, including of commercially valuable species (Bond et al., 2018). Clearly aggregation has occurred, but the evidence does not allow an assessment of the extent to which production has also occurred. This suggests that the Echo Yodel pipeline fits the basic premise of the homogeneous model. It has improved fishing conditions in the vicinity of the pipeline and makes the area a relatively more attractive location for commercial fishing than would have previously been the case without the subsea pipeline infrastructure.

There are significant data limitations in estimating the model for Echo Yodel.

The average annual catch is known. The average price can be estimated so the value of the catch is known. In essence, we can calculate the gross revenue.

However, what the model makes clear is that the estimate required is an estimate of the surplus with and without the pipeline. That is the area abcd +So compared to area abef + So.

The recent catch from the Pilbara Trap fishery is at the upper limit of the acceptable harvest strategy catch range. The removal of Echo Yodel is unlikely to cause a revision of the harvest strategy. Effectively fishers will have the same aggregate harvest targets with or without Echo Yodel.

The impact of the pipeline therefore comes down to fishing costs on and away from the pipeline and the share of the current catch that is on the pipeline. Critical to any assessment is the way fishers adapt their fishing strategies with and without the pipeline.

There is no public data on the share of the catch that currently taken along the Echo Yodel Pipeline. The average harvest cost per unit is not public information and is therefore not available for either the pipeline area or the overall fishery. Detailed surveys of the financial performance of Pilbara demersal fisheries are not available.

Relevant data needs to be obtained directly from fishers or estimated from third party sources.

2.2.1 The role of Echo Yodel in current fishing operations

Discussion with a major trap fishing operator has provided insights into the fishery operation and role of Echo Yodel.

Trap fishing is opportunistic. Fishers place traps where they anticipate good catches but need to move on quickly if catch is poor. Therefore, trap fishers like having proximate locations to try so they do not have to steam far to try the next location. Effectively, they prefer a suite of close substitute locations.

Echo Yodel fits this pattern. It has attractive nearby/surrounding locations. It can be “tried” without great cost. The proximate locations can be accessed quickly.

However, within this approach, Echo Yodel does not get routinely tried. Pipelines are easy to hit and initial fishing is typically good, but then as fishing occurs, the relative advantage disappears quickly. Trap fishers require good stock density, so pipelines are typically good the first time but then become just another location. After the initial effort, pipelines are essentially then hit and miss for traps. Once this occurs, the pipeline location is part of the suite available for opportunistic fishing. No regular share of aggregate fishery catch is coming from Eco Yodel. There is unlikely to be a significant impact on profits from not having it, because it is fished occasionally, perhaps every few years, and alternative locations are available nearby.

In summary, the evidence is that there has been an increase in species available along Echo Yodel, but that it is not an area that is routinely incorporated in annual fishing plans. Rather, it is “pulsed” and then left for a few years.

Arguably, the ongoing benefit is the potential role of the pipeline in the production of feeder stock that then spreads out into the wider environment. Even if the science on this is still uncertain, purely from a commercial fisher perspective, it is better kept than removed.

2.2.2 Indicative estimate of the Commercial Fishing Value of Echo Yodel

The discussions with fishers indicate that, while good to have as another option, Echo Yodel does not play a key role in the fishing strategies for the Pilbara Trap Fishery. Its commercial value is likely modest.

Combining available information on aggregate catch and prices, combined with third party survey data on margins, allows an indicative estimate of this, albeit modest, value.

A survey-based analysis of South Australian marine scalefish operators documented their revenues, fixed and variable costs. Across the operators, the average gross margin (revenue minus variable costs) was 46% of revenue. (BDO EconSearch, 2020). We adopt this as indicative of gross margins in scalefish operations. In 2013, a small sample of Pilbara fishers provided information to the author for analysis as part of a submission into management and compensation decisions. The average gross margin was 47%.

Using the gross margin (revenue minus variable costs) assumes that the fixed costs (licence fees, rent, lease costs etc) would be unaffected by the decommissioning of the pipeline. Although applicable for the short run, in the long run, absent the pipeline, fishers may adjust the configuration of their operations, which could affect fixed costs.

Using the 46% gross margin figure, allows an estimate of the surplus without the pipeline in place. Surplus with the pipeline is the area So plus Ss (=abcd) in Figure 1. Without the pipeline surplus is reduced to area So plus area plus the smaller on-pipeline surplus abef.

To estimate the loss of surplus we need an estimate of area efcd. At this stage we can only make a “best guess” as to the proportion of catch on the pipeline and the cost advantage of fishing on the pipeline.

Figure 3 gives an estimate of the potential lost surplus from removing the fishing opportunity provided by Echo Yodel. It uses current catch (563 tonnes), a high-end price ($6 per kg) and the South Australian fishery gross margin (46%).

Consistent with pulse fishing every few years, it is assumed that, on average, 5% of the catch occurs within the Echo Yodel area and that the improved catchability in pulse years equates to a 10% lower fishing cost per kg for fish caught in the area.

The loss is surplus under these conditions is estimated to be $9,121. The calculation is shown in Table 2.

2.3 SIGNIFICANCE

The estimated surplus loss of $9,121 is around 0.3 percent of estimated industry gross revenue. However, allowing for both variable costs and fixed cash costs (i.e. excluding non-cash costs like depreciation) the net cash income was estimated to be 20 percent of revenue for the South Australian marine scalefish fishery (BDO EconSearch, 2020). Applying this as an indicative estimate for the Pilbara Trap managed Fishery, the estimated loss is around 1.35 percent of the gross revenue in the Pilbara Trap managed Fishery.

Table 2: best Guess Estimate of Lost Commercial Fishing Surplus from loss of Echo Yodel Pipeline.

	Catch(tonnes)	Average Beach Price per Kg	Gross Revenue	Variable Costs as % of Gross Revenue	Variable Costs No Echo Yodel	Gross margin/Surplus - no Echo Yodel	Surplus (price - variable costs) as % of Gross Revenue	Echo Yodel Cost Advantage	Variable Costs	Gross margin/Surplus - Echo Yodel	Surplus Gain from Echo Yodel
Total Catch	563	6	3,378,000	54%	$1,824,120	$1,553,880	46%	0%	1,814,999	$1,563,001	$9,121
% on Echo Yodel	5%										
Catch Echo Yodel	28	6	168,900	54%	$91,206	$77,694	46%	10%	82,085	$86,815	$9,121
Balance Catch	535	6	3,209,100	54%	$1,732,914	$1,476,186	46%	0%	1,732,914	$1,476,186	

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Appendix 10 Map illustrating the interconnectivity of the values highlighting the systemic nature of the values system

Fran Ackermann & Georgina Hill

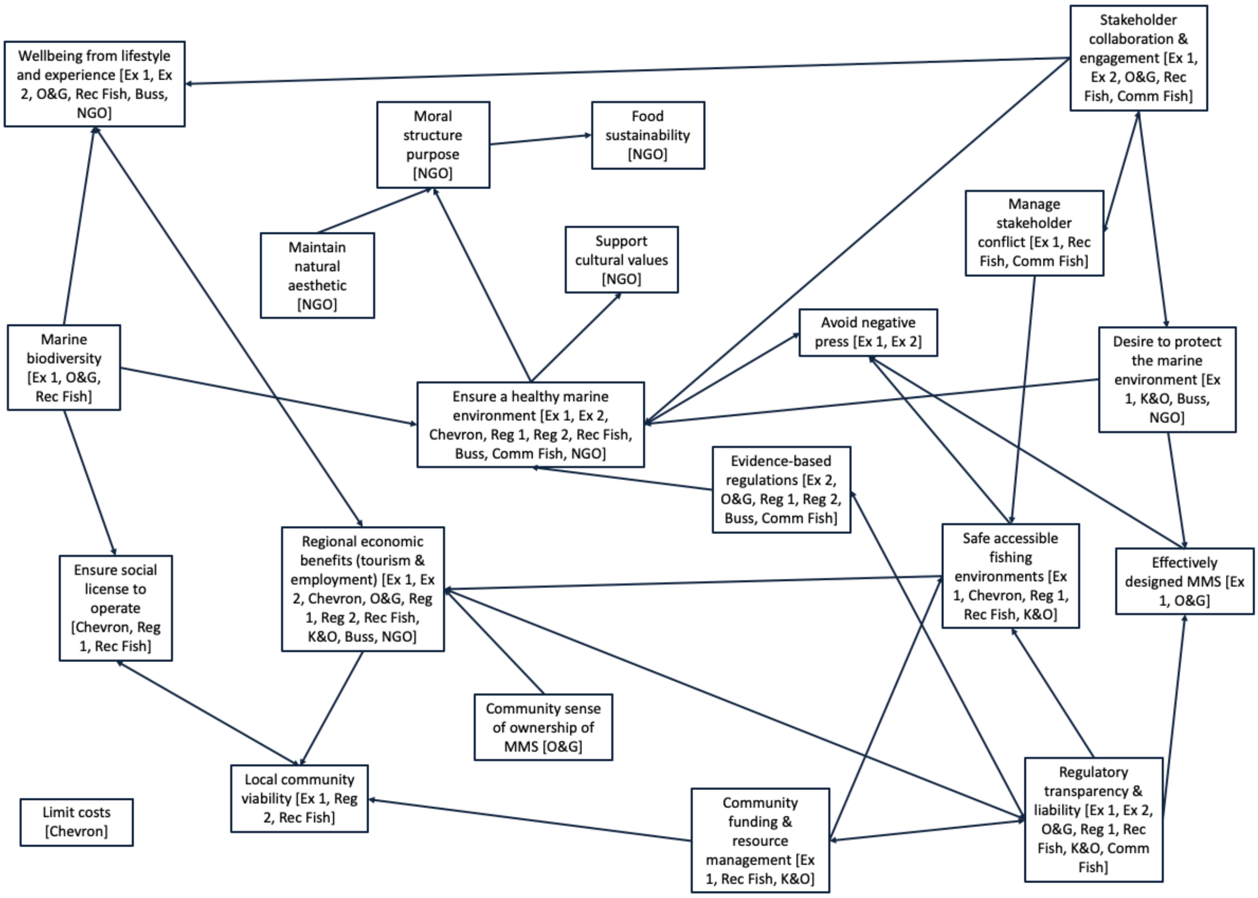
This appendix is part of the final report for:

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

Euan S. Harvey, Fran Ackermann, Michael Burton, Julian Clifton, Carmen Elrick-Barr, Johanna Zimmerhackel, Georgina Hill, Stephen J Newman, Jenny Shaw, Mark Pagano, Paul McLeod, Dianne McLean, Julian Partridge

24th August 2021

FRDC Project No **2018-053**


Wellbeing from lifestyle and experience [Ex 1, Ex 2, O&G, Rec Fish, Buss, NGO]
Stakeholder collaboration & engagement [Ex 1, Ex 2, O&G, Rec Fish, Comm Fish]
Moral structure purpose [NGO]
Food sustainability [NGO]
Maintain natural aesthetic [NGO]
Support cultural values [NGO]
Manage stakeholder conflict [Ex 1, Rec Fish, Comm Fish]
Marine biodiversity [Ex 1, O&G, Rec Fish]
Avoid negative press [Ex 1, Ex 2]
Desire to protect the marine environment [Ex 1, K&O, Buss, NGO]
Ensure a healthy marine environment [Ex 1, Ex 2, Chevron, Reg 1, Reg 2, Rec Fish, Buss, Comm Fish, NGO]
Evidence-based regulations [Ex 2, O&G, Reg 1, Reg 2, Buss, Comm Fish]
Ensure social license to operate [Chevron, Reg 1, Rec Fish]
Regional economic benefits (tourism & employment) [Ex 1, Ex 2, Chevron, O&G, Reg 1, Reg 2, Rec Fish, K&O, Buss, NGO]
Safe accessible fishing environments [Ex 1, Chevron, Reg 1, Rec Fish, K&O]
Effectively designed MMS [Ex 1, O&G]
Community sense of ownership of MMS [O&G]
Limit costs [Chevron]
Local community viability [Ex 1, Reg 2, Rec Fish]
Community funding & resource management [Ex 1, Rec Fish, K&O]
Regulatory transparency & liability [Ex 1, Ex 2, O&G, Reg 1, Rec Fish, K&O, Comm Fish]

Appendix 11 Issues and opportunities underpinning the meta and generic values

Fran Ackermann & Georgina Hill

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Generic and Meta-Values	Contributing Issues and Opportunities
Ensure a healthy marine environment	• Access by disadvantaged people (closer in shore - fish and dive) • Access to sheltered waters • Access to the site opportunities • Additional habitat for fish and corals • Artificial reef infrastructure act as fads rather than areas for fish population growth • Assess the seabed/area e.g. Acidic soils • Avoid putting an artificial on top of a natural • Avoid putting artificial reefs on top of other sensitive areas • Be clear re the objectives of the reef • Be clear who users are • Bleaching damage • Can be used to gain social licence but not suitable for environmental offset • Careful consideration of location • Change in current/ sand movement, impacts to coastal erosion. • Clarify liability issues • Concerns of contaminants from mms on existing environment • Concerns re residual contamination of o&g structure • Contamination potential from old oil and gas infrastructure • Cost of removal could be cheaper than mms remaining because of consultation time, liability and community reimbursement of perceived benefit • Cost reduction for operators may be perceived but not always reality • Cost savings in using existing mms to build artificial reefs over creating new materials for future fisheries enhancement • Creates more living areas/homes for fish stocks greater diversity of fish • Creating new habitat for marine life/coral rehabilitation areas etc • Creation of additional environment for rare/threatened species • Cut down total catch quantum • Damage to natural environment • Decommissioning requirements in commonwealth waters are currently being reviewed - the study could play into this • Depletion of fish stocks from increased effort encouraged by artificial reefs • Different issues and opportunities with decomm of pipelines and other o&g infrastructure • Displacement and impacts on natural marine communities • Do they impinge on perceptions of naturalness • Ease of access to sites - decrease of boat traffic • Easier access for those with limited resources • Easy to find - for those less familiar with reefs • Easy to identify use of the reef (benefits) • Ecosystem research - cryptic species (hard to find) aggregating around structures

	• Employment opportunities through research, fishing and dive charters • Ensuring fishing activities are appropriately regulated to protect fish stocks and the environment • Environmental contamination - potential or otherwise • Establish regulation - duplication/overlap • Establish who is the 'lead' agency - lack of clarity re process wrt to mmi • Future direction of decommissioning considered earlier on in activity planning • If cluster of mms -could act as potential steppingstones for invasive species • Increase awareness and appreciation of what is in the marine environment • Increase of habitat for demersal fish and lobster. Different to mandruah-bunbury-dunsborough. • Increase safety • Increased (man-made) structures for improving commercial and aquaculture production and profitability (o) • Increased ease to get to site - balance between depth and distance from shore/ boat ramp • Increased habitat in barren areas • Increased participation in community engagement through monitoring • Increased pressure on fish stocks from concentrating existing fish around an attraction device • Increased sites for recreation • Increased vertical relief in water column • Increasing carrying capacity (of the environment) at local level • Is this pollution of the sea? [public perception] • Job/employment opportunities • Legal liability of mms left in environment • Less complex decommissioning projects with potential social/environment benefits (in relation to oil and gas infrastructure) minimises impacts to ecosystems that have established around infrastructure. • Liability - long term, when it passes to artificial reef etc. • Lose natural diversity • Maintaining/nurturing marine ecosystems that develop around infrastructure • Managing multi-user risks e.g. Divers vs fishers increased hazards in the environment • Negatively change the natural environment • Obstacle for trolling/trawling - mackerel and wahoo and prawns • Opportunity for fish sanctuaries (no take) • Pier infrastructure changes the ecology of the natural environment • Planning for future decommissioning considered early to use appropriate materials for leaving in situ etc • Potential disruption of current flow

	• Potential environmental impact of the structure itself • Potential for invasive species presence • Potential for transportation of invasive species if structures moved to reefing site • Potential refuge for rare/endangered species • Potential to improve sustainability of commercial fishing industry in Australia • Precedence setting • Protecting new reefs allows for population growth allowing the natural spill over effect • Protection for natural sites by redirecting fishing efforts • Provide for an increase in fish stocks • Public perception of "dumping" of infrastructure • Recognise depth impacts use i.e. >19 meters limits spear fishing • Recognise that regulations work on a case by case basis and that what is accepted for one, might not be for another • Reduce the cost of decommissioning for proponents and general public/governments • Reduced transport of wastes overseas as opposed to retaining our own waste products • Relocate corals etc • Resourcing of infrastructure maintenance in long term • Retain existing habitat for value • Retention of some of the largest structures in the ocean for habitat value • Reuse of material and reduction in waste • Set up dive trails • Set up employment • Spread of pressure on reef systems • Stock depletion from rediverting fish from usual habitat • Threaten natural environment marine and coastal • Trawler damage • With larger fish populations growing on new habitat creating new dive sites
Desire to protect the environment	• Aggregation devices can bring in predators, potentially creating false perception that might be a public hazard • Better understanding of the marine environment (and the impact of mmi) • Better understanding of viability and sustainability of oceans • Carry out monitoring of infrastructure to ensure integrity of structure • Carry out research on environmental impacts • Commercial Fishing • Commercial tourism • Creation of single use areas for specific activities- e.g. fishing only, diving only (no take) for safety and social reasons • Develop a clear understanding of the risks and opportunities associated with MMI - particularly re submerged structures • Fish aggregation possibility of rec fishes depleting stocks. • Great opportunity to work with school kids and raise awareness

	• Keep impact to the environment at reasonable levels • Manage the type and extent of use of MMI • Potential hazard for boats and other water users • Reverse impact of overfishing • Understand the benefits of marine sanctuary • Understand the marine environment - greater awareness - functions • Use for other recreational activities. E.g. Surfing • What is a 'good' number of structures for the environment - are there any long term negative effects known?
Marine biodiversity	• Access by disadvantaged people (closer in shore - fish and dive) • Access to the site opportunities • All structures are removed • Assess the seabed/area e.g. Acidic soils • Avoid putting an artificial on top of a natural • Avoid putting artificial reefs on top of other sensitive areas • Be clear re the objectives of the reef • Bleaching damage • Careful consideration of location • Citizen science and community stewardship of the environment translating to wider environment • Ease of access to sites - decrease of boat traffic • Easier access for those with limited resources • Easy to find - for those less familiar with reefs • Easy to identify use of the reef (benefits) • Fishers to be better engaged in design, site identification, monitoring and assessment • Increase safety • Increased ease to get to site - balance between depth and distance from shore/ boat ramp • Increased habitat • Increased habitats for fish life • Is habitat enhancement the charismatic megafauna of habitat??? • Lack of clear evidence of value of in-situ decommissioning. • New fish habitat • New structures create new habitat for reef fish • NGOs to take the lead creating artificial opportunities. • Obstacle for trolling/trawling - mackerel and wahoo and prawns • Potential habitat for invasive marine species • Potential nursery habitat • Potential nursing/breeding grounds established • Potential repurposing of structures for alternative energy etc • Provides habitat for endangered species • Provides valuable habitat • Recognise depth impacts use i.e. >19 meters limits spear fishing • Recognise different structures will attract different forms of fish - pelagic to reef • Recognise not all increases in fish/ coral life is beneficial

	• Recognition of fishers as leaders in environmental management - not always about murdering fish • Refuge for vulnerable species from over-fishing pressures • Share examples of benefits of environmental stewardship • Social licence for mining industries and recognition of good citizenship as potential offsets • Some structures in deep water provide no benefit for either fish habitat or commercial/recreational use • Trawler damage
Maintain natural aesthetic	N/A
Regional economic benefits (tourism & employment)	• (in relation to oil and gas infrastructure) minimises impacts to ecosystems that have established around infrastructure. • Access to sheltered waters • Access to the site opportunities • Aging/breakdown of man-made structures over time • Applying user pays model to eco-tourism • Attract and retain staff - local govt, tourism providers etc • Become more attractive to the Asian market • Broader applicability for rivers and man-made freshwater impoundments • Carry out monitoring of infrastructure to ensure integrity of structure • Carry out research on environmental impacts • Change in current/ sand movement, impacts to coastal erosion. • Charter and commercial fishing access competing with other users • Collaborations with other countries with 50+ years' experience e.g. China. Japan, Vietnam • Commercial Fishing • Commercial fishing target o&g structures • Commercial tourism • Consideration of whole ecosystem impact not simply 1-2 species/outcomes • Constraints in sharing fishery resources, sees policy look to "growing the pie" • Cost of ongoing maintenance • Create new industry sector re removal and management of infrastructure • Creating new habitat for marine life/coral rehabilitation areas etc • Creation of additional environment for rare/threatened species • Creation of diverse fishing opportunities • Creation of single use areas for specific activities- e.g. fishing only, diving only (no take) for safety and social reasons • Damage to natural environment • Delay in actions (e.g. Dispute) • Develop a clear understanding of the risks and opportunities associated with MMI - particularly re submerged structures

	• Develop ocean/water based tourism facilities for a small town of Onslow (850 pax) • Disruption of established marine ecosystems from decommissioning • Duty of care/responsibility for site use • Eco-tourism vs consumptive use of resultant structures • Economic diversification - tourism, commercial fishing. • Economic multiplier to towns through employment, local spend, accommodation etc. • Ecosystem research - cryptic species (hard to find) aggregating around structures • Employment opportunities through research, fishing and dive charters • Enhance economic viability and diversity • Ensuring fishing activities are appropriately regulated to protect fish stocks and the environment • Fisher conflict with other user groups particularly inshore infrastructure • Increase of habitat for demersal fish and lobster. Different to mandruah-bunbury-dunsborough. • Increase quality abundancies - re marine biodiversity particularly fish stocks • Increase the number of people coming to k and o • Increased (man-made) structures for improving commercial and aquaculture production and profitability • Increased hazards in the environment • Increased market and collaboration • Increased vertical relief in water column • Increasing carrying capacity (of the environment) at local level • Increasingly loss of fishing access from land-based infrastructure i.e. Ports • Job/employment opportunities • K have a bigger town and open government • Keep impact to the environment at reasonable levels • Lack of understanding of benefits to tourism • Less complex decommissioning projects with potential social/environment benefits • Local economies enhancement through increased and diverse opportunities • Lose natural diversity • Maintaining/nurturing marine ecosystems that develop around infrastructure • Manage different demands of stakeholders from divers to recreational fishers • Manage the type and extent of use of MMI Fish aggregation possibility of rec fishes depleting stocks. • Managing multi-user risks e.g. Divers vs fishers • Managing/mitigating potential environmental harm • Need for ongoing monitoring • Onslow perfect location apart from cyclone season

	• Potential hazard for boats and other water users • Potential hazard for boats and other water users • Potential to improve sustainability of commercial fishing industry in Australia • Preserving maritime heritage • Provide additional social benefit • Provide job opportunities • Provide opportunities for education - allow marine life to be viewed in situ • Provides for new fishing experiences • Recreational fishing opportunities • Reduce the attractiveness of k and o • Regional economies disproportionally benefit from fishing related enhancement • Regional interests competing for benefits • Relocate corals etc • Research and data • Reverse impact of overfishing • Risk of accident or injury - user safety • Risk that the existing infrastructure not able to cope • Risks to user safety • Seabed lease terminated/responsibility for removing structure • See a range of repurposing uses from fish friendly locations to wind farms • See increased collaboration between all marine users • See large surge of decommission cases • Set up dive trails • Set up employment • Shore based infrastructure often overlooked as benefits to community and disabled as well as habitat (e.g. Melbourne jetties, Busselton) • Spatial and temporal access between sectors. • Take a very broad interpretation of compliance - beyond laws/ regulations (include policy, best practice) • Threaten natural environment marine and coastal • Understand social and environmental impacts of removing man made marine structures • Understand the benefits of marine sanctuary • Understanding long term environmental impacts of leaving (or creating) infrastructure (can include altering sand movement, construction material, selection, etc • Use as an environmental/fishing offset to other industrial activity • Use for other recreational activities. E.g. Surfing • Volunteers get fed up and stop doing it - burn out • Well defined regulatory frameworks for understanding of all stakeholders • What is a 'good' number of structures for the environment - are there any Long term negative effects known? (I)

Safe, accessible fishing environments	• Assess the seabed/area e.g. Acidic soils • Carefully consider location of mmi • Consider pollutants re the artificial reef materials • Develop coastal management plan (weather fronts, tidal changes) • Increased debris • Increased hazards in the environment • Managing multi-user risks e.g. Divers vs fishers • Monitor/avoid invasive species e.g. Barnacles on ships, O&G etc. • Potential for pollution • Potential to improve sustainability of commercial fishing industry in Australia • Provide opportunities for education - allow marine life to be viewed in situ • Really deep structures require different maintenance regimes and associated costs • Recognise different structures have different rates of marine growth • Regularly used e.g. Recreational fishing structures require more maintenance • Size and depth of structures - possible collision on low/hide tide?
Local community viability	• Applying user pays model to eco-tourism • Broader applicability for rivers and man-made freshwater impoundments • Charter and commercial fishing access competing with other users • Constraints in sharing fishery resources, sees policy look to "growing the pie" • Creation of diverse fishing opportunities • Eco-tourism vs consumptive use of resultant structures • Fisher conflict with other user groups particularly inshore infrastructure (• Increase quality abundancies - re marine biodiversity particularly fish stocks • Increasingly loss of fishing access from land-based infrastructure i.e. Ports • Lack of understanding of benefits to tourism • Local economies enhancement through increased and diverse opportunities • Provide additional social benefit • Provides for new fishing experiences • Regional economies disproportionally benefit from fishing related enhancement • Regional interests competing for benefits • Shore based infrastructure often overlooked as benefits to community and disabled as well as habitat (e.g. Melbourne jetties, Busselton) • Spatial and temporal access between sectors. • Use as an environmental/fishing offset to other industrial activity

Community funding & resource management	• Additional biological information being available • Applying user pays model to eco-tourism • Assess the seabed/area e.g. Acidic soils • Broader applicability for rivers and man-made freshwater impoundments • Charter and commercial fishing access competing with other users • Citizen science and community stewardship of the environment translating to wider environment • Consider pollutants re the artificial reef materials • Constraints in sharing fishery resources, sees policy look to "growing the pie" • Create new fit-for-purpose fishing opportunities • Creation of diverse fishing opportunities • Desire for a one size fits all approach • Eco-tourism vs consumptive use of resultant structures • Ensure good financial assessment and management is carried out for any mmi • Explore both horizontal (breadth of scope - social versus economic etc) and vertical (assessment of type and design of mmi) analysis • Fisher conflict with other user groups particularly inshore infrastructure • Fishers to be better engaged in design, site identification, monitoring and assessment • Funding for research into best designs (seems to be left to the private sector) • Identifying critical life stages to recruitment and whether they can be enhanced with habitat • Increase quality abundancies - re marine biodiversity particularly fish stocks • Increased debris • Increasingly loss of fishing access from land-based infrastructure i.e. Ports • Is habitat enhancement the charismatic megafauna of habitat??? • Lack of learning culture from across Australia • Lack of understanding of benefits to tourism • Local economies enhancement through increased and diverse opportunities • Measuring the social and economic impact of fishing from man-made structures • Monitor/avoid invasive species e.g. Barnacles on ships, O&G etc. • NGOs to take the lead creating artificial opportunities. • Often limited information on biological benefits / impacts to species or stocks • Possibility to export learnings and designs to the world • Potential for pollution • Prove objectives for fishing/eco productivity through robust science • Provide additional social benefit

	• Provides for new fishing experiences • Question whether structures aggregate or produce more fish • Recent discourse around "purpose built" impacting views on repurposing structures as fish habitat • Recognition of fishers as leaders in environmental management - not always about murdering fish • Reduced pressure on nearby targeted areas • Regional economies disproportionally benefit from fishing related enhancement • Regional interests competing for benefits • Share examples of benefits of environmental stewardship • Shore based infrastructure often overlooked as benefits to community and disabled as well as habitat (e.g. Melbourne jetties, Busselton) • Social licence for mining industries and recognition of good citizenship as potential offsets • Spatial and temporal access between sectors. • Use as an environmental/fishing offset to other industrial activity •
Food sustainability	N/A
Ensure social licence to operate	• Applying user pays model to eco-tourism • Approvals processes associated with decommissioning are not currently streamlined or matured in Australia • Aust decomm policy uncertain & lagging. If follow e.g. Us, with any cost benefit going back to community - creates uncertainty with o&g operators. • Broader applicability for rivers and man-made freshwater impoundments • Charter and commercial fishing access competing with other users • Citizen science and community stewardship of the environment translating to wider environment • Concern that proponents are walking away from obligation to remove structure • Constraints in sharing fishery resources, sees policy look to "growing the pie" • Creation of diverse fishing opportunities • Eco-tourism vs consumptive use of resultant structures • Fisher conflict with other user groups particularly inshore infrastructure (• Fishers to be better engaged in design, site identification, monitoring and assessment • Future port use, limiting future port operations due to installation and nav risk • If cluster of mms -could act as potential steppingstones for invasive species • Increase quality abundancies - re marine biodiversity particularly fish stocks • Increasingly loss of fishing access from land-based infrastructure i.e. Ports

	• Is habitat enhancement the charismatic megafauna of habitat??? • Lack of understanding of benefits to tourism • Local economies enhancement through increased and diverse opportunities • Long term liability, who owns if proponent walks away • Navigational hazard for general shipping • NGOs to take the lead creating artificial opportunities. • Policy not able to keep pace with resource sharing issues • Political challenges for decommissioning • Potential for invasive species presence • Potential for transportation of invasive species if structures moved to reefing site • Potential refuge for rare/endangered species • Provide additional social benefit • Provides for new fishing experiences • Recognition of fishers as leaders in environmental management - not always about murdering fish • Reduced area access or snagging risk for trawl fishing • Regional economies disproportionally benefit from fishing related enhancement • Regional interests competing for benefits • Resourcing of infrastructure maintenance in long term • Retain existing habitat for value • Retention of some of the largest structures in the ocean for habitat value • Share examples of benefits of environmental stewardship • Shore based infrastructure often overlooked as benefits to community and disabled as well as habitat (e.g. Melbourne jetties, Busselton) • Social licence for mining industries and recognition of good citizenship as potential offsets • Spatial and temporal access between sectors. • Use as an environmental/fishing offset to other industrial activity
Wellbeing from lifestyle and experience	• Change in current/ sand movement, impacts to coastal erosion. • Commercial Fishing • Commercial tourism • Counter act impact of social media • Creating new habitat for marine life/coral rehabilitation areas etc • Creation of additional environment for rare/threatened species • Creation of single use areas for specific activities- e.g. fishing only, diving only (no take) for safety and social reasons • Damage to natural environment • Ecosystem research - cryptic species (hard to find) aggregating around structures • Encourage curiosity interest in environment • Fish aggregation possibility of rec fishes depleting stocks. • Help local ownership through education • Increase of habitat for demersal fish and lobster. Different to mandruah-bunbury-dunsborough.

	• Increased vertical relief in water column • Keep impact to the environment at reasonable levels • Lose natural diversity • Manage the type and extent of use of MMI • Potential hazard for boats and other water users • Provide education to users (and potential users) • Relocate corals etc • Tap into schools, universities etc. • Threaten natural environment marine and coastal • Use for other recreational activities. E.g. Surfing
Avoid negative press	• Assess the seabed/area e.g. Acidic soils • Consider pollutants re the artificial reef materials • Increased debris • Monitor/avoid invasive species e.g. Barnacles on ships, O&G etc. • Potential for pollution
Support cultural values	N/A
Moral structure purpose	• Create offshore detention centres or quarantine areas for pandemics • Extract ammonia from produced water to make hydrogen gas • Hydrogen gas - repurpose oil and gas infrastructure to make hydrogen gas from seawater • Offshore aquaculture facilities, energy production through wave energy generators, kelp farms for carbon capture. • Re-use of o&g infrastructure
Stakeholder collaboration & engagement	• All structures are removed • Balance and take account of opportunities and risks of different stakeholders • Balancing risks of leaving in the marine environment versus impacts of disposing onshore trade off • Carefully consider location of mmi • Complete removal of infrastructure can create a new industry (e.g. North sea) • Difficulty of removal • Ensure a safe environment for recreational as well as commercial users • Ensure structures are safe to use e.g. Navy pier shut down • Hazard for users of ocean long term - degradation (environmental) • Lack of clear evidence of value of in-situ decommissioning. • Lack of long-term monitoring data to evaluate positive/negative impacts • No baseline data pre-installation for many structures to compare changed environment • Potential habitat for invasive marine species • Potential nursery habitat • Potential repurposing of structures for alternative energy etc • Provides habitat for endangered species • Really deep structures require different maintenance regimes and associated costs

	• Recognise not all increases in fish/ coral life is beneficial • Recognise that structures will need to either support commercial fishing or recreational structures • Refuge for vulnerable species from over-fishing pressures • Size and depth of structures - possible collision on low/hide tide? • Some structures in deep water provide no benefit for either fish habitat or commercial/recreational use • Unable to compare what was to what is to demonstrate benefits (big data gaps) • Unknown future environmental hazards that the leaving of infrastructure in-situ may create • What is our baseline for environmental impacts? Pre-trawling and man-made impacts to benthic habitats or now?
Community sense of ownership of MMS	N/A
Manage stakeholder conflict	• Access by disadvantaged people (closer in shore - fish and dive) • Access control to prevent overuse • Access to the site opportunities • Assess the seabed/area e.g. Acidic soils • Avoid putting an artificial on top of a natural • Avoid putting artificial reefs on top of other sensitive areas • Be clear re the objectives of the reef • Biased consultative processes designed to reinforce philosophy - stop when get answer you want • Bleaching damage • Careful consideration of location • Carry out more targeted research on the role and value of habitat with clear objectives and outcomes • Charter and commercial fishing access competing with other users • Chicken little opposition to any benefits being claimed • Citizen science and community stewardship of the environment translating to wider environment • Citizen science engagement. • Commercial fishers e.g. Aquarium take considerable fish • Commonwealth actually recognises recreational fishing • Competition between commonwealth/state/local government - only want credit - blame others early and often • Consider reefs for conservation, for diving, for rec fish and for commercial • Constraints in sharing fishery resources, sees policy look to "growing the pie" • Cynicism in community about government motives • Cynicism in community about government motives • Ease of access to sites - decrease of boat traffic • Easier access for those with limited resources • Easy to find - for those less familiar with reefs • Easy to identify use of the reef (benefits) • Eco-tourism vs consumptive use of resultant structures

	• Encourage stakeholders to take a more sophisticated view re use of decommissioning rather than simplistic view • Ensure effective engagement with and between all stakeholders • Ensure regulations/ legislation is informed by science and transparent/consistent rather than snap judgements or regulatory constipation • Entrenched views about (against) man-made structures as fish habitat / fishery enhancement • Establishment of standards, playbook and goal setting to make future processes easier • Fisher conflict with other user groups particularly inshore infrastructure • Fishers to be better engaged in design, site identification, monitoring and assessment • Fundamentalism in commonwealth government policy • Government red tape and ideological opposition across government • Increase risk of collisions • Increase safety • Increased ease to get to site - balance between depth and distance from shore/ boat ramp • Increased habitat in barren areas • Increased sites for recreation • Insistence on environmental destruction as part of rehabilitation process (cutting pipes off below surface) • Insufficient stakeholder consultation. • Is habitat enhancement the charismatic megafauna of habitat??? • Legal issues around risk and responsibility • Legitimise capping of stocks, use of reefs • Local economies enhancement through increased and diverse opportunities • Long-term upkeep/safety of structure • Management of conflicting activities (e g fishing whilst divers present • Mining companies using fishing as a front to cover for unsustainable practices • Navigating government planning and approvals process • Need to ensure monitoring and communication of monitoring results • Needs to be a dedicated person to facilitate the issues outside of the fisheries department with power • NGOs to take the lead creating artificial opportunities. • Obstacle for trolling/trawling - mackerel and wahoo and prawns • Perception and ideology of conservation and environmental groups • Poor legacy of materials of opportunity being used in the past only to degrade / cause environmental issues • Protecting new reefs allows for population growth allowing the natural spill over effect • Protection for natural sites by redirecting fishing efforts

	• Provide additional social benefit • Provides for new fishing experiences • Recognise competing interest • Recognise depth impacts use i.e. >19 meters limits spear fishing • Recognition of fishers as leaders in environmental management - not always about murdering fish • Regional interests competing for benefits • Rotate sites between users (recognising initial funding) • Share examples of benefits of environmental stewardship • Social licence for mining industries and recognition of good citizenship as potential offsets • Spatial and temporal access between sectors. • Spread of pressure on reef systems • Stock depletion from rediverting fish from usual habitat • Synergies between industries enhancing social licence • Trawler damage • Variability within and across government departments to approvals and principles • Very poor legislation stopping all these issues. • Water quality from disused platforms • Who owns the infrastructure and the associated risk/liability? • With larger fish populations growing on new habitat creating new dive sites
Evidence-based regulations	• Balancing access rights between competing user groups • Can be used to gain social licence but not suitable for environmental offset • Clarify liability issues • Collaboration between industry and government evolving discussion • Commercial Fishing • Commercial tourism • Creation of single use areas for specific activities- e.g. fishing only, diving only (no take) for safety and social reasons • Decommissioning policy and regulatory uncertainty • Decommissioning requirements in commonwealth waters are currently being reviewed - the study could play into this • Do they affect water movement • Duty of care/responsibility for site use • Establish regulation - duplication/overlap • Establish who is the 'lead' agency - lack of clarity re process wrt to mmi • Fish aggregation possibility of rec fishes depleting stocks. • High quality diving site due to habitat complexity and species diversity • Keep impact to the environment at reasonable levels • Legislation isn't keeping up with current scientific knowledge • Liability - long term, when it passes to artificial reef etc. • Liability - who is responsible • Lots of existing rov footage etc in the o&g industry that could be analysed

	• Lots of o&g infrastructure coming to the end of its life that could be used in the study • Manage the type and extent of use of MMI • May be difficult to quantify wider benefits/impacts of structures in the marine environment e.g. How they may be used as ecological corridors/linkages, nurseries etc. • Multiple layers of federal and state policy and regulation in this space • Net environmental benefit analysis - expanding on tools available for demonstration • O&G case studies to review where sea dumping permits have been approved – e.g. Exmouth king reef, pttep jabiru rtm and challis salram, conoco elang/kakatua rtm • Ongoing legislative and regulatory reform for petroleum decommissioning • Potential fish population depletion if not managed properly with fishing restrictions • Potential hazard for boats and other water users • Precedence setting • Recognise that regulations work on a case by case basis and that what is accepted for one, might not be for another • Reduce regulatory uncertainty • Regulatory obligations need to be met • Remain complaint with international regulations • Research into production vs attraction • Research opportunities gained from mmi • Sharing of potential additional resources between user groups • Use for other recreational activities. E.g. Surfing • What is there social value
Regulatory transparency & liability	• Artificial reef infrastructure act as fads rather than areas for fish population growth • Be clear who users are • Benefits of commercial and recreational fishing on mms • Can be used to gain social licence but not suitable for environmental offset • Carefully consider location of mmi • Carry out more targeted research on the role and value of habitat with clear objectives and outcomes • Charter and commercial fishing access competing with other users • Clarify liability issues • Commonwealth actually recognises recreational fishing • Competition between commonwealth/state/local government - only want credit - blame others early and often • Concern that proponents are walking away from obligation to remove structure • Constraints in sharing fishery resources, sees policy look to "growing the pie" • Contamination potential from old oil and gas infrastructure • Coordination and dissemination of information to industry

	• Counter act impact of social media • Cynicism in community about government motives • Decommissioning requirements in commonwealth waters are currently being reviewed - the study could play into this • Difficulty of removal • Discover that there are hazards from long term in situ • Do they impinge on perceptions of naturalness • Eco-tourism vs consumptive use of resultant structures • Encourage curiosity interest in environment • Ensure a safe environment for recreational as well as commercial users • Ensure structures are safe to use e.g. Navy pier shut down • Environmental contamination - potential or otherwise • Establish regulation - duplication/overlap • Establish who is the 'lead' agency - lack of clarity re process wrt to mmi • Establishment of standards, playbook and goal setting to make future processes easier • Fisher conflict with other user groups particularly inshore infrastructure • Fundamentalism in commonwealth government policy • Future direction of decommissioning considered earlier on in activity planning • Giving a targeted point for research in the habitats of marine flora and fauna • Government red tape and ideological opposition across government • Hazard for users of ocean long term - degradation (environmental) • Help local ownership through education • Implement monitoring programs to understand the impacts and level of activity • Is this pollution of the sea? [public perception] • Lack of relevant experience holding back the issue. • Legal issues around risk and responsibility • Legal liability for impacts to users of the sea • Liability - long term, when it passes to artificial reef etc. • Local economies enhancement through increased and diverse opportunities • Long term liability, who owns if proponent walks away • Manage safety issues re diving, fishing on the structure or trawl fishing ships being damage • Many benefits with research, fishing recreational use and environmental growth • Navigating government planning and approvals process • Navigational hazard for e.g. Trawlers snagging structures • NGOs to take the lead creating artificial opportunities. • Opportunity to test novel techniques for building resilience in marine communities in face of climate change • Ownership of long term residual liability

	• Planned augmentation of structures in design phase • Planning for future decommissioning considered early to use appropriate materials for leaving in situ etc • Poor legacy of materials of opportunity being used in the past only to degrade / cause environmental issues • Possible disruption of msc processes • Potential cost benefit of carbon remaining in ecosystem (future blue carbon calculations) • Precedence setting • Provide additional social benefit • Provide education to users (and potential users) • Provides for new fishing experiences • Public perception of "dumping" of infrastructure • Really deep structures require different maintenance regimes and associated costs • Recognise that regulations work on a case by case basis and that what is accepted for one, might not be for another • Recognise that regulations work on a case by case basis and that what is accepted for one, might not be for another • Recognise that structures will need to either support commercial fishing or recreational structures • Reduced transport of wastes overseas as opposed to retaining our own waste products • Regional interests competing for benefits • Research value added (tweaking the reef) of mmi • Resolve question of do they aggregate or augment a stock • Resourcing of infrastructure maintenance in long term • Reuse of material and reduction in waste • Scientific opportunity to study growth on structure and how long it takes • See teaming life on pipeline highway • Share examples of benefits of environmental stewardship • Size and depth of structures - possible collision on low/hide tide? • Spatial and temporal access between sectors. • Steppingstones of hard substrate (platform to platform) for introduced and potential pest species to invade new habitats • Tap into schools, universities etc. • Understanding the cost-benefit economic life cycle analysis to capture short term benefits (smelting) offset against long term benefits (fisheries) • Unknown and generally poorly researched environmental impacts of man-made infrastructure • Variability within and across government departments to approvals and principles • Water quality from disused platforms • What is the most productive material for structure • Who owns the infrastructure and the associated risk/liability?
Effectively designed MMS	• Able to gain evidence of benefits of artificial reefs

	• Increased participation in community engagement through monitoring • Set up comparison sites
Limit costs	• Concern that proponents are walking away from obligation to remove structure • Cost of removal could be cheaper than mms remaining because of consultation time, liability and community reimbursement of perceived benefit • Cost reduction for operators may be perceived but not always reality • Cost savings in using existing mms to build artificial reefs over creating new materials for future fisheries enhancement • Different issues and opportunities with decomm of pipelines and other o&g infrastructure • Legal liability of mms left in environment • Long term liability, who owns if proponent walks away • Reduce the cost of decommissioning for proponents and general public/governments • Resourcing of infrastructure maintenance in long term

Appendix 12 Assessing the Social and Economic Value of Man-made Marine Structures: A Guidebook

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This appendix is part of the final report for:

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

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FRDC Project No **2018-053**

Assessing the Social and Economic Value of Man-made Marine Structures: A Guidebook

Introduction

This guidebook provides support to those making decisions regarding the design, installation, adaptation and maintenance of man-made marine structures (e.g. policy makers, private sector managers): their use, development, placement and management. In particular, it guides users in selecting an approach to evaluate the social and economic values associated with man-made marine structures (MMS). The definition of MMS is broad, including: existing infrastructure (e.g. O&G or wind turbines), in particular when this infrastructure is decommissioned and either left *in situ* or re-located; manmade reefs; wrecks (purposefully or accidentally occurring); and piers and jetty's. The guidebook has been developed based on an identified need to support stakeholders in understanding the social and economic values of man-made marine structures and their underpinning rationale for those values across a range of sectors. Thus stakeholders will be able to incorporate this understanding within their decision-making.

Aiding Decision-Makers
Good decisions take place when a detailed and nuanced understanding is held of the situation/topic. Carrying out social-economic analysis provides valuable insight into a) the breadth of stakeholder values, b) the impact values have on one another and c) identification of economic and social values and opportunities that inform sustainable, supported, and nuanced decision outcomes.

By understanding the importance people place on the marine environment, the infrastructure within it, and its associated uses, a more informed case can be made for the installation or removal of MMS, taking into account considerations such as effective resource allocation, community engagement, and the wider context (thus avoiding unsustainable decisions from being made).

Scope of the guidebook

The guidebook was created as an output of an FRDC funded research program entitled 'Enhancing the Understanding of the Value Provided to Fisheries by Man-made Aquatic Structures' (Project No

2018-053). In this project, the social and economic values (also collectively termed 'social-economic values') of man-made marine structures were elicited for structures within Western Australia. The learnings from this project informed the design of this guidebook. The guidebook focuses predominantly on the methodologies that were applied in this project. However, there exist alternate and complementary approaches and methodologies that can obtain the desired information. Some such methodologies are discussed herein (e.g. stakeholders interviews), but the methodologies captured in this guidebook are not definitive. For further information on the range of social and economic assessment methods, refer to, for example: Bickman and Rog 2008 (social research) and Pannell et al (2013) (who provide a framework for evaluation of environmental projects from an economic perspective).

Social-economic values defined

Social and economic values associated with man-made marine structures are the 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. Social-economic values are shaped by, and shape an individual's perceptions and behaviours, can be either positive or negative, and interact and change over space and time. Values therefore evolve in response to the social, economic, political and environmental context.

Why understand social and economic values?

Decommissioning Oil and Gas structures
When oil and gas infrastructure comes to the end of its operational life, a decision has to be made about how it is disposed of. Evaluating the economic values of alternative end states quantifies in monetary terms the benefits to different users different of decommissioning alternatives, while understanding the social values of stakeholders impacted (both directly and indirectly) can provide information to support decision-making on the options that will best address (i) social licence to operate; (ii) potential stakeholder conflicts; and (iii) provide social benefit to multiple stakeholders.

Designing Artificial Reefs
Artificial reefs can play an important role in environmental sustainability, protecting erodible coastlines, and as sites of subsistence, commercial and recreational activities. An assessment of the economic value of an artificial reef can provide the business case for its implementation and/or explore the potential value trade-offs across stakeholder groups (e.g. recreational fishers and divers) based on site location and user access. Social value assessments can, for example, contribute an understanding of stakeholders' views on artificial reefs and how these compare across sites or stakeholders, uncover potential stakeholder conflicts relating to access; and demonstrate the benefits or impacts to multiple stakeholders.

How to use this guidebook

In the following sections, we guide you through the identification of social and economic values, commencing with economic followed by social valuation approaches. A pre-cursor to this is, in some cases, the identification of the consequences of the MMS on the ecological system. For example, the quantification of economic and social values can require a quantification of the changes in the ecological values associated with the change in status of the MMS. Or there may be no changes in the ecological system *per se* (e.g. changing access to an MMS), but there will still be a need to understand the change in environment that is being made *accessible*. The guidebook has been designed on the assumption that this information has been (or will be) obtained, if required.

At the start of each section, we briefly describe the nature of the values that can be identified. By navigating through the questions, users are provided with one or more approaches they can adopt to understand social and/or economic values. For both, different approaches can give information of different depths, and these are described.

The approaches are classified into three categories reflecting a different depth of understanding: basic, medium and detailed. A basic level of understanding of social and/or economic values of MMS might be sufficient where stakeholders have limited concerns or only have a limited budget. A basic level of understanding also might be enough where stakeholders do not desire to build a case to influence policy or where the alternatives are non-controversial. A detailed assessment might be necessary when regulators require an in-depth level of understanding of a case study (e.g. to accept a certain decommissioning scenario), where stakeholder's interests could be affected (particularly in situations where there can be competing interest), or when alternative scenarios of the management of MMS are complex.

Social and economic valuation approaches provide different yet complementary information. While the approaches are presented separately, they can be combined for more comprehensive and robust coverage, to inform subsequent methods and/or to answer multiple questions. For example, a survey-questionnaire can identify and quantify social and economic values, while a focus group workshop can understand the nuance of survey elicited preferences and their impact on one another. For other examples of the benefits of integrating social and economic values see Harvey et al (2021).

Integrating information on social and economic values

There are several ways to integrate social and economic research. Data from a survey could be augmented through a focus group which seeks to understand the values in more depth. For example, triggers (e.g. safe access) or opportunities (e.g. refuge for endangered species) can be identified. The survey data can also be examined against economic data to determine where perception and fact diverge.

Understanding Economic Values

The defining aspect of economic values is that they are represented in monetary terms. This includes values that may be determined through markets (e.g. profits or expenditures), but also values that may be seen as intangible (e.g. the value of the recreational experience to the fisher). Placing all values in a common monetary metric allows for an easy comparison of outcomes across different stakeholders. Man-made marine structures can generate various value types for different stakeholder groups. These values include:

- *Commercial value:* The impact on commercial enterprises that directly interact with the MMS e.g. commercial fishers who may fish on the structures. This would typically be measured through changes in profits.
- *Recreational user value:* The benefits to the recreational users of MMS through that use, which is measured by the 'consumer surplus' associated with their use. This is the direct benefit to those users (recreational fishers, divers, tourists etc), and which should be differentiated from:
- *Community value:* The contribution of users of MMS to the local/regional economy through their expenditures, and potentially measured through the jobs that are supported by that expenditure
- *Existence value:* The values that the community may hold for changes in the ecological conditions arising from the MMS, that arise simply from it occurring, without any need for the person to directly interact with the MMS. For example, this could be positive if the MMS improves the status of endangered species that are valued by the community, or negative if the presence of the MMS is deemed to compromise those values.
- *Subsistence and cultural value:* The values a community may derive from the direct consumption of fish harvested due to the MMS (food security), or the ability to maintain cultural usage of marine resources.

It is important to frame values by a counterfactual: what value does this infrastructure in the water provide, compared to the situation where it is removed – what additional value would the creation of this MMS provide, compared to the situation where it is not. Quantifying the counterfactual is necessary and challenging, as one needs to identify the full extent of people's adaptation in behaviour in response to the change in the state of the MMS.

A particular value can be quantified in different ways. Table 1 gives an overview to the different approaches that quantify these values in monetary terms, including the consumer surplus and existence values. These approaches generate different levels of understanding: from those that are relatively low in resource needs, and which may generate relatively imprecise values (Basic), to those that are medium or high in resource needs, can be framed to be context specific, and which can give a richer and more accurate insight into the values (Medium/Detailed). The table also gives a summary of the main outputs one gets from each of the approaches.

Which approach might be the most suitable can be further explored in the question section below. Each of these approaches could stand alone, or they could be combined, depending on the interest of the user of this guidebook. For example, if there is a mixed fishery around the MMS, approaches on commercial and subsistence fisheries apply. Moreover, some approaches can estimate more than one value type. A Random Utility Model of site choice for instance can quantify the value to recreational user, and also estimate community values (expenditures) associated with that activity.

Economic Value: Section 1 Recreational users

Q1 Is there a potential recreational use of MMS (recreational fishing, diving, and/or other tourism)?

No: Go to Economic Value: Section 2

Yes: Q2 Is there currently any recreational use in the region of a (prospective) MMS?

No: Q3 Could the MMS create new recreational use?

No: Go to Economic Value: Section 2

Yes: Q4 Are you interested in:

Recreational user value?
Community value?

Existing and/or new MMS
Basic: *Benefit transfer*

Yes: Q5 Are you interested in:

Recreational user value?

Existing and/or new MMS
Basic: *Benefit transfer*
Detailed: *Random Utility Model*
Existing MMS only:
Medium: *Travel cost method*

Community value?
Existing and/or new MMS
Basic: *Benefit transfer*
Medium: *Random Utility Model*
Detailed: *Economic impact assessment*

Existing MMS only:
Medium: *Travel cost method*

Economic Values: Section 2 **Commercial fisheries**

Q6 Is there a potential commercial fishery on the MMS?

No: Go to Economic Values: section 3

Yes: Q7 Is there any commercial fishery in the region of the (prospective) MMS?

No: Q8 Could the (prospective) MMS create new commercial fisheries?

No: Go to Economic Values: section 3

Yes:

Basic: *Benefit transfer*

Yes:

Basic: *Benefit transfer*
Medium/detailed: *Survey of commercial enterprises*

Economic Values: Section 3 **Subsistence fisheries**

Q9 Is there any subsistence fishery in the region of the (prospective) MMS?

No: Go to Economic Values: section 4

Yes:

Basic: *Benefit transfer*

Detailed: *Sustainable livelihood assessment*

Economic Values: Section 4 **General public**

Q10 Is there any sign that the MMS potentially generates non-use/existence values to the general public?

No: There are no further economic values, you may want to continue to social values.

Yes:

Basic: *Benefit transfer*
Medium/detailed: *Contingent Valuation Method/Discrete Choice Experiment*

Question	Sub-question	Level of understanding	Primary Output	Approach
Recreational users	Recreational user value	Basic	Aggregate consumer surplus based on non-case study specific user values that users derive/lose from the provision/removal of MMS	*Benefit transfer*
		Medium	Case study specific consumer surplus per trip and on aggregate that users lose from the removal of MMS	*Travel cost method*
		Detailed	Change in use of MMS and the region at large	*Random Utility Model*
			Case study specific consumer surplus per trip and on aggregate that users derive/lose from the provision/removal of MMS	
	Community value	Basic	Aggregate market value based on non-case study specific community values that users derive/lose from the provision/removal of MMS	*Benefit transfer*
		Medium	Market value per trip and on aggregate that users lose from the removal of MMS	*Travel cost method*
		Medium	Change in use of MMS and the region at large	*Random Utility Model*
			Case study specific market value per trip and on aggregate that users derive/lose from the provision/removal of MMS	
		Detailed	Case study specific market values per trip and on aggregate that users derive/lose from the provision/removal of MMS	*Economic impact assessment*
Commercial fisheries	Commercial value	Basic	Aggregate market values based on non-case study specific commercial values that users derive/lose from the provision/removal of MMS	*Benefit transfer*
		Medium to detailed	Case study specific aggregate market value of commercial fishery that users derive/lose from the provision/removal of MMS	*Survey of commercial enterprises*
Subsistence fisheries	Food security	Basic	Non-case study specific aggregate market price of fisheries catch	*Benefit transfer*
	Social-economic and cultural values	Detailed	Economic, social and/or cultural impact of MMS on the livelihood of subsistence fishers. Can identify pathways to enhance, supplement and/or diversify livelihoods	*Sustainable livelihood assessment*
General public	Existence value	Basic	Aggregate consumer surplus based on non-case study specific existence values that people derive/lose from the provision/removal of MMS	*Benefit transfer*
		Detailed	Case study specific per unit and aggregate existence values that people lose from the removal of MMS	*Contingent Valuation Method/Discrete Choice Experiment*
			Use value that people would derive/lose from the provision/removal of the MMS	

Table 1: Management questions, level of understanding sought, and associated outputs provided by different economic valuation approaches.

Understanding Social Values

Social value can be seen as denoting the degree of importance of an object or action, with the aim of determining what actions are best to do, or what way is best to live, or to describe the significance of different actions in relation to a societal decision. Social values are influenced by, and influence, how people interact with and view man-made marine structures. In regard to social values and their use in the management, design and implementation of man-made marine structures, there are often three core areas of interest:

- Understanding how people use or interact with MMS
- Understanding the values that people derive from MMS
- Understanding people's perceptions of MMS (including the opportunities and issues associated with MMS)

Each of the three areas of interest could comprise a standalone question or they could be combined depending on the stakeholders' interest, for example, whether they seek a partial or 'whole of system' understanding. Each area is interrelated: an individual's perceptions can influence their behaviour, which in turn can shape their values; an individual's values can influence their perceptions and in turn their behaviours; finally, an individual's actions can change their perceptions and values (Figure 1).

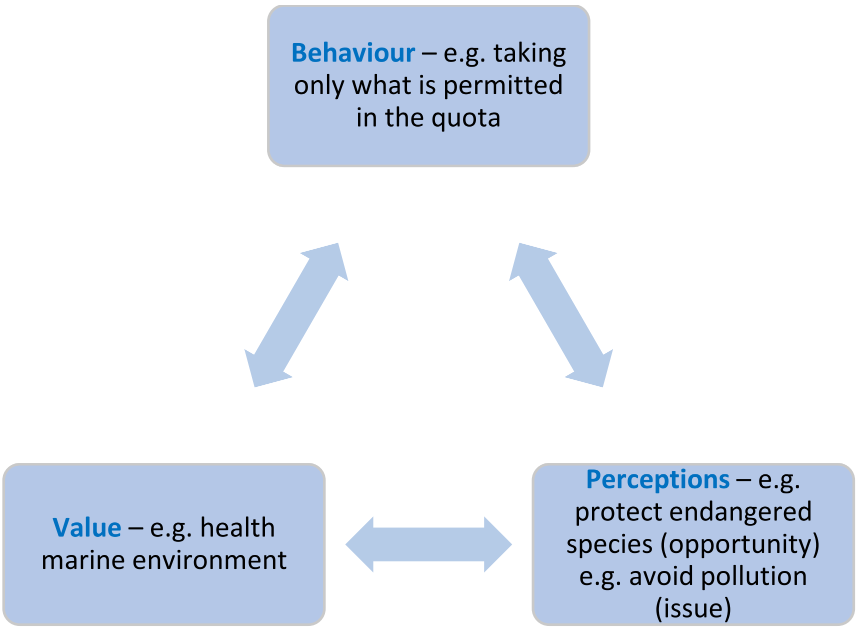

Figure 1: Illustration of core areas of interest showing their interactive nature

Furthermore, for each question, there are different levels of understanding that can be obtained, and different data collection techniques that contribute to that level of understanding. We broadly describe these across three levels:

1. Basic: Provides a partial understanding of use/behaviour/ values/perceptions of stakeholders. Does not provide information on what influences uses/behaviours.

2. Moderate: Provides an understanding of the uses/values/perceptions and the factors influencing use/values/perceptions; but does not explain why those influencing factors are important or how values, behaviours, and perceptions interrelate.
3. Detailed: Provides the information missing from the two prior levels of understanding, i.e. explanation for the influencing factors and any interrelationships between behaviour/values/perceptions.

We summarise these in the boxes below and then present them as questions leading to alternate approaches.

Why conduct a social values assessment?

Decommissioning Oil and Gas Structures

Understanding perceptions of key stakeholders in order to decide whether or not to convert a platform to an artificial reef.

- Basic understanding – number of society pro or against a rigs to reef decision
- Moderate understanding – a sense of which values are affected by the decision and to what degree
- Detailed understanding – articulation of the range and interconnectivity of the issues (e.g. invasive species) and opportunities (protecting endangered species)

Policy Makers

If seeking to modify stakeholders' use of an existing structure, understanding the values and perceptions of stakeholders to support equitable decisions that can reduce potential conflicts arising from management choices.

- Basic – number of users of the current structure and potential users of the modified structure
- Moderate – insight into how different groups perceive the modification (positively or negatively) and why (values associated).
- Detailed – comprehensive understanding of the different appetites for the modification along with explanations regarding the perceived issues and opportunities associated.

Peak Body

If seeking to present the case for installation (or maintenance) of an MMS, understanding the values users obtain (or could obtain) from these structures is important.

- Basic – number of interested parties, % of sampled population
- Moderate – information regarding the impact on a set of values affected by the installation (positively/negatively)
- Detailed – understanding of the range of concerns held by the community e.g. services overloaded, ambience of location adversely affected

It is important to note that the level of detail obtained through application of different social research methods varies depending on the design and implementation of the tool. For example, an online survey questionnaire can include short, multiple choice questions sent to a discrete number of stakeholders, or it could include i) multiple Likert scale questions based on existing literature or theoretical models, or ii) open-ended questions and be distributed to a representative sample of stakeholders. In general, however, the depth of understanding gained through approaches lies on a continuum from Basic to Detailed as shown in Figure 2:

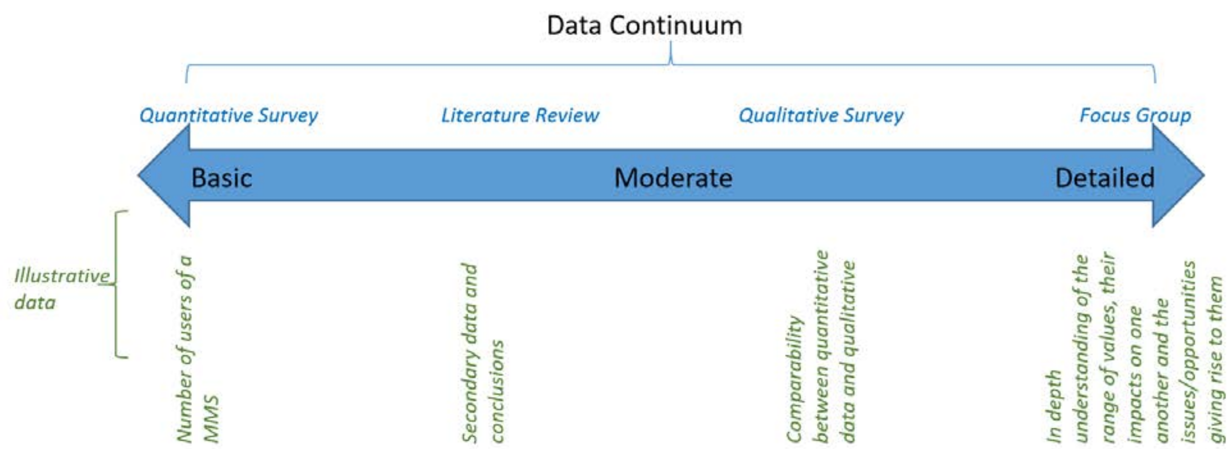

Figure 2: Social value data continuum

See Social Value: Approaches, for further detail on each approach.

To help guide the selection of a research method, let's consider ***what you would like to know:***

1. **How people use or interact with MMS**
    a. Do you want to know who uses MMS?
        i. If Yes apply: *Quantitative survey (online or face-to-face)*
    b. Would you also like to know why they are using MMS?
        i. If Yes apply: *Literature review and/or Quantitative survey (online or face-to-face) and/or Focus group/Workshop*

2. **People's perceptions/views on MMS**
    a. Do you want a basic understanding of people's views of MMS?
        i. If Yes apply: *Quantitative survey (online or face-to-face)*
    b. Do you want a moderate level of understanding of how people's views differ and what influences their views?
        i. If Yes apply: *Literature review and/or Quantitative and Qualitative survey (online or face-to-face) and/or Focus group/Workshop*
    c. Do you want a detailed and systemic understanding of people's views so that you can explain why those views are held and what influences them and plan outcomes that are more likely to be accepted (social licence)?
        i. If yes, apply: *Qualitative survey (online or face-to-face), and/or Interviews and/or Focus group/Workshop*

3. The values people derive from MMS

a. Do you want a moderate level of understanding of the values people derive from MMS and potential influencing factors?
    i. If yes, *Literature review and/or Quantitative and Qualitative survey (online or face-to-face)*

b. Do you want to be able to explain why those values are held, what are the issues and opportunities underpinning the values, how they change over time, how they impact on one another and the degree of homogeneity in values?
    i. If yes, apply: *Interviews and/or Focus group/Workshop*

Table 2: Management questions, level of understanding sought, and associated outputs provided by different data collection approaches

Question	Sub-question	Level of understanding	Output	Approach
1) Use of MMS	a) Who uses MMS	Basic	Number of users	Quantitative survey *(online or face-to-face)*
	b) Why are they using MMS	Moderate	Number of users	Literature review
			Influencing factors	Quantitative survey *(online or face-to-face)*
		Detailed	Number of users	Literature review
			Influencing factors	Quantitative survey *(online or face-to-face)*
			Explanation	Qualitative survey *(online or face-to-face)*, Interviews, *Focus group/Workshop*
2) Perceptions of MMS	a) General perceptions	Basic	Ranking	Quantitative survey
	b) Sub-groups of perceptions (e.g. by stakeholder group or MMS type)	Moderate	Ranking	Literature review
			Influencing factors	Quantitative survey *(online or face-to-face)*
		Detailed	Ranking	Literature review
			Influencing factors	Quantitative survey *(online or face-to-face)*
			Explanation	Qualitative survey *(online or face-to-face)*, Interviews, *Focus group/Workshop*
3) Values of MMS	a) General values	*Basic not possible*		
		Moderate	Ranking	Literature review
			Influencing factors	Quantitative survey *(online or face-to-face)*
	b) Sub-groups of perceptions (stakeholder group / MMS type)	Detailed	Ranking	Literature review
			Influencing factors	Quantitative survey *(online or face-to-face)*
			Explanation	Qualitative survey *(online or face-to-face)*, Interviews, *Focus group/Workshop*

Approaches

Economic Value: Approaches

In this section, the advantages and limitations of different approaches are summarised, and examples of their application provided.

Benefit transfer

Advantages

- Does not require any (or limited) primary data collection
- Potentially can be applied to any of the economic values identified.

Disadvantages

Requires there to be values in the literature that are relevant to the current context, and those values become less reliable the further from the current context those values are drawn from (e.g. transferring values across countries, or different ecological systems)

Input Requirements

- Access to (or creation of) a literature base from which to identify relevant values
    - The Environmental Valuation Reference Inventory www.evri.ca is a database for non-market values such as the consumer surplus of recreational users and existence values held by the general public
    - For commercial activities (e.g. fisheries or tourism) one needs market values such expenditures or profits
    - For subsistence fisheries one needs the market value of the catch.
- Given values are often per unit (e.g. value per trip), the quantum of use (e.g. number of trips, volume of fish caught) still needs to be estimated.

Outputs

- Estimate of the aggregate value, in monetary terms associated with the MMS.

Examples

- "The potential Economic Value Associated with the Development of Artificial Reefs in Western Australia" in Harvey et al (2021) Appendix 4.

Literature Examples

- Rogers, A.A., Nedosyko, A., McLeod, I.M., Gillies, C. and Burton, M.P. (2018). Benefit-Cost Analysis of the Windara shellfish reef restoration project. Report to the National Environmental Science Program, Marine Biodiversity Hub. The University of Western Australia
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- Food and Agriculture Organisation (2005) Increasing the contribution, role and importance of small-scale fisheries in poverty alleviation and food security. FAO Fisheries Technical Paper No.481, Rome, Italy.

Travel cost method

Advantages

- Is based on observed behaviour
- Is relatively easy to implement in terms of data requirements

Disadvantages

- Can only be used to value an existing MMS, not prospective MMS, as it relies on a survey of users.
- It can only identify the recreational use values (and the expenditures associated with them) but not existence values.

Input Requirements

- There are a variety of methods available, which differ in the data collected, but all require a survey that identifies the level of use by individuals, and an estimate of the costs they incurred in order to access the MMS. Mostly commonly employs an on-site survey.
- If sufficiently comprehensive, the survey will provide an estimate of the aggregate use of the MMS, otherwise an external source for that information is required.

Outputs

- Estimate of the "consumer surplus" per trip to the MMS (i.e. the value to the user over and above the amount they have spent on the activity).
- Combination of the value per trip and an estimate of aggregate use leads to an estimate of the value of the MMS to the users.
- If information on all costs is collected (i.e. both travel and local expenditure), estimates of the value of the activity to the regional economy can also be generated.

Examples

- Appendix 5 "The Economic Value of the Exmouth Navy Pier and Busselton jetty, Western Australia" in Harvey et al (2021) "Enhancing the Understanding of the Value Provided to Fisheries by Man-made Aquatic Structures", FRDC project No 2018-053.

Literature Examples

- Chen J., Chuang C., Jan R., Liu L., Jan M. (2013) Recreational benefits of ecosystem services on and around artificial reefs: a case study in Penghu, Taiwan. Ocean and Coastal Management, 85: 58-64.
- Lupi,F., Phaneuf,D.J., von Haefen,R. (2020) Best practices for implementing recreational demand models. *Review of Environmental Economics and Policy*, volume 14, issue 2, Summer 2020, pp. 302–323
- Pendleton L. (2005) Creating underwater value: The economic value of artificial reefs for recreational diving. Report for the San Diego Oceans Foundation, San Diego, USA.

Random Utility Model

Advantages

- Is based on observed behaviour
- Once developed it can simulate the consequences (and hence value) of prospective MMS at different locations
- It can identify the substitution effects arising from the change in MMS i.e. the way that users shift effort in space as a result of removing/introducing an MMS

Disadvantages

- It can only identify the recreational use values (and the expenditures associated with them) but not existence values.
- It has a relatively data intensive approach, requiring information on all site choices that are possible substitutes for the MMs of interest (i.e. diving trips to natural sites as well as to the MMS that one may be interested in), and a full complement of data about all potential sites, even if not selected by a respondent.

Input Requirements

- Data from a survey of users identifying all relevant trips within the area of interest, including site specific information on costs of accessing site, and expectations (or proxies thereof) of the expected outcomes/experience of the visit (e.g. expected catch rates, species caught, expected species seen). This data needs to be extrapolated to all available 'sites' even if an individual has not visited them through e.g. an estimated expected catch function.
- Statistical analysis is relatively complex.

Outputs

- Estimate of the "consumer surplus" per trip to a specific MMS (i.e. the value to the user over and above the amount they have spent on the activity), derived through simulating their site choices with the MMS present v those when it is not.
- Combination of the value per trip and an estimate of aggregate use leads to an estimate of the value of the MMS to the users.
- An estimate of the change in use (i.e. visitation rate/level of effort) applied at the MMS and ***all other sites*** as a result of MMS removal/creation.
- If information on all costs is collected (i.e. both travel and local expenditure) estimates of the value of the activity to the regional economy can also be generated.

Examples

- Appendix 6 "The use value of man-made marine structures in Western Australia: A random utility model" in Harvey et al (2021) "Enhancing the Understanding of the Value Provided to Fisheries by Man-made Aquatic Structures", FRDC project No 2018-053.

Literature Examples

- Raguragavan, J., and Hailu, A. (2013). Economic valuation of recreational fishing in Western Australia: statewide random utility modelling of fishing site choice behaviour. *Australian Journal of Agricultural and Resource Economics*. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1111/1467-8489.12009.

Economic impact assessment

Advantages

- Can quantify the monetary value that an MMS contributes to the economy in a specified area
- Is based on observed behaviour

Disadvantages

- Strictly speaking, the relevant measure of the economic impact is the business profit. However, this measure is typically hard to quantify because few businesses are willing to provide this sensitive information. This is why other measures are used as proxy for profit.

Input Requirements

- Data from users on expenditures associated with an activity on a MMS
- Interview(s) with relevant businesses on employment, expenditures in the local economy and profits

Outputs

- Value is typically measured as direct and indirect business revenues, employee salaries and job creation and/or business profit

Examples

- Appendix 4 "The potential Economic Value Associated with the Development of Artificial Reefs in Western Australia" in Harvey et al (2021) "Enhancing the Understanding of the Value Provided to Fisheries by Man-made Aquatic Structures", FRDC project No 2018-053.

Literature Examples

- Brock (1994). Beyond fisheries enhancement: Artificial reefs and ecotourism. Bulletin of Marine Science, 55(2-3): 1181-1188.
- Brandini (2014). Marine biodiversity and sustainability of fishing resources in Brazil: a case study of the coast of Parana state. Reg. Environ. Change, 14: 2127-2137
- Crabbe M., McClanahan T.R. (2006). A biosocioeconomic evaluation of shipwrecks used for fishery and dive tourism enhancement in Kenya. Western Indian Ocean J. Mar. Sci., 5(1): 35-53.
- Dowling R.K., Nichol J. (2001). The HMAS Swan Artificial Dive Reef. Annals of Tourism Research, 28(1): 226-229.

Contingent Valuation Method/Discrete Choice Experiment

Advantages

- The only approach that can identify the existence values associated with a change in MMS that are held by those who do not directly use the MMS
- Can potentially capture both use and non-use values if the definition of the sample used is representative and sufficiently large.

Disadvantages

- Based on stated preferences, in hypothetical contexts.
- Can potentially conflate existence values and use values, so may lead to double counting if one has estimates of use value elsewhere in the analysis.
- Can be relatively resource intensive if a large representative study is to be undertaken.

Input Requirements

- A survey of the relevant population, who may hold values for the outcomes associated with changes in MMS. Typically this will need to be 1000+ for robust results, and if subsectors within the sample are to be identified.
- There are a variety of approaches that can be employed, depending on the specific context: contingent valuation techniques are relatively straight forward, but value the MMS as a whole, while the more complex discrete choice models allow the decomposition of value between the elements of the MMS, and allow one to value prospective MMS provision.

Outputs

The existence values associated with the MMS, held by those who may never use the MMS. Potentially, given the sampling frame and the context of the question (e.g. a national reefing program) it may include user's evaluation of the use value that they would derive/lose from the provision/removal of the MMS (as respondents are typically asked to value the resource, and not categorise the source of those values). If information on actual (or prospective) use is included then one may be able to segregate different groups of stakeholders, and draw inferences about why values may be different. If a representative sample is drawn, then aggregate values can be made for regional or national populations.

Examples

- Appendix 7 "Community perceptions of rigs-to-reefs in Western Australia" in Harvey et al (2021) "Enhancing the Understanding of the Value Provided to Fisheries by Man-made Aquatic Structures", FRDC project No 2018-053.

Literature Examples

- Börger T., Hooper T.L., Austen M.C. (2015) Valuation of ecological and amenity impacts of an offshore windfarm as a factor in marine planning. Environmental Science and Policy 54: 126-133.
- Chi-Ok Oh, Robert B. Ditton & John R. Stoll (2008) The Economic Value of Scuba-Diving Use of Natural and Artificial Reef Habitats, Society & Natural Resources, 21:6, 455-468, DOI: 10.1080/08941920701681953

- Morgan O.A., Huth W.L., Hindsley P. (2018) Examining the perceptions and effects of survey consequentiality across population subgroups. J. Benefit Cost Anal., 9(2): 305-322. doi:10.1017/bca.2017.32

Survey of commercial enterprises

Advantages

- One gets direct estimates of the economic data relevant to identify profits of commercial enterprises working with the MMS
- Can provide detailed information on expenditure/jobs potentially at a regionally specific level.

Disadvantages

- Unless a sector is entirely dependent on the MMS one has to infer contribution of MMS to the aggregate profit
- High level of detail required, and dependent on cooperation of industry to provide commercially sensitive information

Input Requirements

- A survey of the relevant population, identifying information on costs and revenues, preferably at a level of disaggregation that allows one to attribute values to the MMS of interest.

Outputs

- Estimates of profit per unit output/effort, that reflect the economic value of the activity to the business.
- Estimates of the total expenditure, which may give indication of the contribution to local economies.

Literature Examples

Pascoe, S., Innes, J., Tobin, R., Stoeckl, N., Paredes, S. and Dauth, K. (2016) Beyond GVP: The value of inshore commercial fisheries to fishers and consumers in regional communities on Queensland's east coast July 2016 FRDC Project No 2013-301

Sustainable livelihood assessment

Advantages

- Can identify and estimate a wide range of impacts on subsistence fisheries (economic, social, cultural)
- Is able to integrate economic and social approaches to assessing values
- Applies an ecosystem-based approach to fisheries management

Disadvantages

- In contrast to other classical economic approaches, this approach does not quantify all impacts in monetary terms

Input Requirements

- Surveys with relevant members of the fisheries community to collect information on diversity of coastal people, their capacity to adapt to risks, the incentives that influence their decisions and sources of their vulnerability.

Outputs

- Economic, social and/or cultural impact of MMS on the livelihood of subsistence fishers
- Can identify pathways to enhance, supplement and/or diversify livelihoods

Literature Examples

- Pomeroy R.S. (2013) Sustainable livelihoods and an ecosystem approach to fisheries management. Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security Report, Jakarta, Indonesia.
- Islam et al. (2014) Economic impact of artificial reefs: A case study of small scale fishers in Terengganu, Peninsular Malaysia. Fisheries Research 151: 122-129.

Social value: Approaches

In this section, the advantages and limitations of different approaches are summarised, and examples of their application provided. While the approaches are separated here, they can be combined for more comprehensive coverage, to inform subsequent methods or to answer multiple questions. See for example: Harvey et al 2021, Evans et al 2017, Barclay et al 2017.

The 'best' approach will vary depending on the depth of information sought, the target group, the education and engagement levels sought, available resources, and geographic scope. Appendix 1 provides a 'checklist' from which users of this guidebook can quickly see the advantages and disadvantages of the different data collection techniques. By adopting more than one approach, the limitations of one can be offset by another. This is termed data triangulation.

Literature Review

Advantages

- Does not require independent data collection which can be time and resource intensive
- Provides a baseline that can be used to guide/inform future research.

Disadvantages

- If a topic of limited current knowledge, a literature review will provide limited contribution to understanding your questions
- The findings are often not related to your specific context (e.g. different geographic location; different user groups) and therefore whether the outputs are transferrable to your context remains unclear in the absence of independent data collection.

Input Requirements

- Time to complete the review
- Cost of accessing literature databases (e.g. Universities have licences to access these systems)

Outputs

Provides a broad understanding of the depth and breadth of current knowledge in relation to the research question. This knowledge may or may not be specific to the location or users of interest to the individual conducting the literature review.

The results can be used to inform/guide additional research into the proposed questions. For example, the literature review may identify key topics that are of interest; and/or provide examples and lessons that inform/shape future research.

Examples

- Appendix 2, "Socioeconomic Values Associated with Man-made Aquatic Infrastructure Academic Literature Review" in Harvey et al (2021) "Enhancing the Understanding of the Value Provided to Fisheries by Man-made Aquatic Structures", FRDC project No 2018-053.

Literature Examples

- Sutton S.G., Bushnell S.L. (2007) Socio-economic aspects of artificial reefs: Considerations for the Great Barrier Reef Marine Park, Ocean and Coastal Management, 50(10): 829-846
- Stolk P., Markwell K., Jenkins J.M. (2007) Artificial reefs as recreational scuba diving resources: A critical review of research, Journal of Sustainable Tourism, 15(4): 331- 350
- Lima, J.S., Zalmon, I.R. and Love, M., 2019. Overview and trends of ecological and socioeconomic research on artificial reefs. Marine Environmental Research, 145: 81-96.

Online Survey (Quantitative, Qualitative or both)

Advantages

- Low cost of data collection due to limited researcher costs
- Obtain large sample sizes through maintaining active survey online
- Random choice of respondent, hence no researcher bias associated with sampling
- Automated recording of responses in format amenable for statistical analysis
- Able to provide incentives to boost response rates if necessary
- Low cost of subscription to well-known and professionally managed survey sites (e.g. Qualtrics)
- Survey can be retitled and given online URL with a catchy or memorable phrase to aid publicity

Disadvantages

- Survey cannot be overlong, hence tendency to focus on methods to achieve quick responses (Likert scale; closed option responses) which do not provide opportunity for respondent comment, reaction or discussion
- Limited opportunity for triangulation to verify responses
- No control over choice of respondent: potential for bias due to multiple or duplicate responses requires surveyor to verify each survey response manually
- Unable to ensure respondents are representative of a particular stakeholder group or population
- Limits respondents to those with internet access
- Lack of interaction with surveyor opens possibility for respondent misunderstanding of questions
- Slight risk of survey being hacked or respondent data otherwise illegally accessed. Complete respondent anonymity is usually essential.

Input requirements

- Time costs are mostly incurred when designing the survey. Questions and sub-routines (eg 'if answer to Q1 is Yes, then skip to Q5') must be completely internally consistent. All questions must be completely clear, with no words or phrases that could be interpreted in a different way. Instructions to respondent must be absolutely clear and as simple as possible. Survey must be road tested by multiple respondents to ensure that there are no 'dead ends' or incorrect sub-routines through the survey.
- Having designed the survey, costs are minimal. The only costs required are occasional checking of the survey status online and the costs of promotion and/or advertising.

- Analysis costs will vary, but if the survey is mostly quantitative then automated processes of data conversion and analysis can be used. Any qualitative responses (i.e. 'have you any comments to make on X') must be treated separately and coded manually for analysis, which can be time consuming.

Outputs

- End users obtain a highly detailed dataset of mainly quantitative responses to questions. These can be analysed as a whole (e.g. X% of survey respondents stated that...), cross tabulated to show relationships between variables or subjected to a wide variety of more advanced analysis and modelling. The choice of technique depends upon the objective of the research, but given a sufficient sample size, a wide range of techniques are available.
- If qualitative questions are employed then these can enrich data analysis through providing direct insights into why respondents answer questions in a certain way. Quotations also enhance the impact of the final report.

Examples

- See Sections 'Social Value Individual', in Harvey et al (2021) "Enhancing the Understanding of the Value Provided to Fisheries by Man-made Aquatic Structures", FRDC project No 2018-053.

Literature examples

- Kirkbride-Smith A.E., Wheeler P.M., Johnson M.L. (2013) The Relationship between Diver Experience Levels and Perceptions of Attractiveness of Artificial Reefs - Examination of a Potential Management Tool, PLoS ONE, 8(7)
- Belhassen, Y., Rousseau, M., Tynyakov, J., & Shashar, N (2017) Evaluating the attractiveness and effectiveness of artificial coral reefs as a recreational ecosystem service, Journal of Environmental Management, 203 (1): 448 – 456
- Sue,V.M., Ritter,L.A. Conducting online surveys (2011) Sage Publishing

In-person Survey (Quantitative, Qualitative or both)

Advantages

- Ability to clearly explain and clarify any questions respondents have to ensure accurate interpretation of survey questions
- Ability to obtain more detailed responses to open-ended survey questions, as respondents are often more willing to 'discuss' their views, than to physically write them down.
- Control over the choice of respondents to ensure they are representative of the target stakeholder group

Disadvantages

- Survey cannot be overlong, as interviewee is often taking peoples time from their work or recreation activities; therefore there is a tendency to focus on methods that achieve a quick response (i.e. the inclusion of Likert scale, close option responses) despite the ability for more in-depth interaction with respondents.
- Higher costs of data collection, as requires researchers to physically meet and run-through survey with each participant

- Potential research bias as targeting select groups. To avoid bias, strategies such as surveying every X number of users, can be adopted.
- Smaller sample sizes as constrained by researcher times/costs and site-collection
- Depending on collection technique, e.g. hand written at point of collection, can require additional time to convert responses into digital database/record

Input requirements

- Time and travel costs associated with getting to survey sites and data collection
- Analysis costs will vary, but if the survey is mostly quantitative then automated processes of data conversion and analysis can be used. Any qualitative responses (e.g. 'have you any comments to make on X') must be treated separately and coded manually for analysis, which can be time consuming.

Outputs

- End users obtain a geographically-specific or user-specific dataset of mainly quantitative responses to questions. These can be analysed as a whole (e.g. X% of survey respondents stated that...), cross tabulated to show relationships between variables or subjected to a wide variety of more advanced analysis and modelling. The choice of technique depends upon the objective of the research, but given a sufficient sample size, a wide range of techniques are available.
- If qualitative questions are employed then these can enrich data analysis through providing direct insights into why respondents answer questions in a certain way. Quotations also enhance the impact of the final report.

Literature Examples

- Ramos, J., Santos, M., Whitmarsh, D., & Monteiro, C. (2011b) Stakeholder analysis in the Portuguese artificial reef context: winners and losers, Braz. J. Oceanogr, 59: 133-143
- Hooper T., Ashley M., Austen M. (2015) Perceptions of fishers and developers on the co-location of offshore wind farms and decapod fisheries in the UK, Marine Policy, 61: 16- 22
- Shani A., Polak O., Shashar N. (2012) Artificial Reefs and Mass Marine Ecotourism, Tourism Geographies, 14 (3): 361-382

In-person or online Interviews

Advantages

- Ability to obtain more detailed responses than open-ended survey questions and in-person surveys, as respondents are able to more broadly discuss their views, rather than being confined to answering set discrete questions. The interviewee also has the ability to ask additional questions and delve more deeply into specific topics that are raised during the interview process
- Interviews are conducted over a long period of time (e.g. average of 1 hour) allowing ample opportunity to explore a topic/question in-depth.
- Control over the choice of respondents to ensure they are representative/key stakeholders of the target stakeholder group

- The descriptive nature of interviews provides useful quotes that can applied to demonstrate key research themes or to provide additional depth to quantitative research if being conducted in combination with quantitative methods.

Disadvantages

- Higher costs of data collection, as requires time to conduct, transcribe and analyse transcripts each interview. Specialist skills in social research required for data analysis.
- Potential research bias as targeting select stakeholders.
- Smaller sample sizes as constrained by researcher times/costs and (when not conducted online) site-collection

Input requirements

- Time and travel costs associated with getting to survey sites (for in-person interviews) and data collection
- Analysis costs will vary depending on the number of interviews conducted, but each interview must be coded manually for analysis, which can be time consuming.

Outputs

- End users obtain an in-depth understanding of the target issue, from the perspective of the interviewees
- If coupled with other research techniques, such as surveys, interviews provide an enriched data analysis through providing direct insights into why respondents answer questions in a certain way. Quotations also enhance the impact of the final report.

Literature Examples

- Lima J.S., Zappes C.A., Di Beneditto A.P.M., Zalmon I.R. (2018), Artisanal fisheries and artificial reefs on the southeast coast of Brazil: Contributions to research and management, Ocean and Coastal Management,163: 372-382
- Pike, K., Johnson, D., Fletcher, S., Wright, P., & Lee, B (2010), Social Value of Marine and Coastal Protected Areas in England and Wales, Coastal Management, 38(4): 412 - 432
- Ten Brink T.S., Dalton T. (2018) Perceptions of commercial and recreational fishers on the potential ecological impacts of the Block Island Wind Farm (US), Frontiers in Marine Science, 5: 439

Workshops/Focus groups

There are multiple techniques for running group workshops/focus groups. In this section we focus on three approaches, all involving causal mapping – a structuring technique. Two of the approaches adopt software (as applied in Harvey et al, 2021), and one that does not apply software. See Table 3 below for a summary. However, it is also possible to run focus groups with a facilitator capturing the views on a flip chart, using brainstorming to generate material into content-oriented clusters, or simple group electronic prioritisation systems.

Table 3 Illustrating the techniques

Technique/application	Manual F2F	Software supported F2F	Software supported on-line
Causal mapping – structured conversations	Use of Oval Mapping	Group Explorer	*Strategyfinder*
Brainstorming	Facilitator as scribe Post it exercise on wall	Group electronic prioritisation systems	Miro and other software packages

Face to face software supported mapping-oriented focus groups

Advantages

- Able to capture a wide range of issues and opportunities through participants having direct entry allowing for simultaneous contribution = highly productive use of time
- Reduce conformity pressures through anonymity allowing for greater openness and thus representativeness of view
- Capture participant's contributions accurately rather than risks of paraphrasing or getting lost = ownership increased
- Able to understand how issues and opportunities impact one another and thus capture the systemic nature of the focal issue – better systemic understanding
- Ability to identify clusters - content oriented themes - helping participants navigate the material and ensuring that complexity is managed, not simply reduced.
- Ability to ask why issues matter enabling participants to reflect on values that drive them rather than responding to provided values (bounded list) or those that are currently topical and given lip service to -> Able to tease out values 'in action' – those that are acted upon and drive behaviour
- Able to prioritise themes, issues, values and opportunities to determine degree of consensus as well as priorities
- Able to develop a network of issues, opportunities and values (through chains of argument) which can be analysed for key properties such as dominant issues/opportunities, feedback dynamics etc and can feed into more quantitative models. A series of workshops can be reviewed and analysed to determine intra and inter levels of homogeneity etc.
- Enables participants to gain a deeper more nuanced understanding of the topic being focused upon and increased ownership for outcomes

Disadvantages

- Complex maps which are challenging to read by those not involved in generating them

- An array of issues to tackle when considering MMS (or whichever topic is focused upon) which may feel overwhelming and may raise expectations in the minds of those involved
- Non quantifiable data but the map's structure can be used to develop quantifiable models (e.g. MCDM, SD simulations etc.)

Input requirements

- 3-3.5 hours participant time
- Software availability
- Facilitator time (including time expended for set up, managing the workshop, analysing the data, producing the report)
- Trained facilitators
- Group Support System equipment
- Appropriate venue

Outputs

- Policy makers are provided with a clear sense of the priorities, concerns and aspirations of particular communities/cohorts and how these impact one another – thus able to make more robust and sustainable decisions
- Policy makers/local government have clarity re competing values/aspirations of stakeholder groups - enabling increased 'buy-in' and facilitating communication
- Policy makers are able to use the information to feed into semi-quantitative and quantitative models (through provision of structure) for further analysis
- Oil and Gas industry are able to make decisions about decommissioning which take account of community views (both issues and opportunities)
- Regulators are provided with a mandate to work with stakeholder groups to develop effective and evidence based (informed by identified research needs) regulations reflecting the diversity of values
- Recreational and Commercial fishing decision makers are given insight into the competing uses
- Participants gain a deeper understanding of the topic, allowing them to understand more effectively their own views and seeing them in the context of others thus building shared understanding, alignment of view and a platform for action
- All are made aware of the multiple different stakeholder cohorts and the variations of issues, opportunities and values both within and across cohorts

Examples

- See Sections 'Social Value Group', in Harvey et al (2021) "Enhancing the Understanding of the Value Provided to Fisheries by Man-made Aquatic Structures", FRDC project No 2018-053.

Literature Examples

- Ackermann, F. and Eden, C. (2020) Group Support Systems: Concepts to Practice. In C. Eden and M. Kilgour (Eds) Handbook of Group Decision and Negotiation. Springer
- Bryson, J., F. Ackermann, and C. Eden. 2016 **"**Discovering Collaborative Advantage: The Contributions of Goal Categories and Visual Strategy Mapping. Public Administration Review 76 p912-925

- Franco, L.A., Rouwette, E.A.J.A. (2011) Decision development in facilitated modelling workshops. European Journal of Operational Research, 2011, 212(1), pp. 164–178

On-line software supported mapping based focus groups

Advantages

- Able to capture a wide range of issues and opportunities through participants having direct entry allowing for simultaneous contribution = highly productive use of time
- Reduce conformity pressures through anonymity allowing for greater openness and thus representativeness of view. On line system yields greater degrees of anonymity and also provides time for reflection increasing quality of surfaced material
- Capture participant's contributions accurately rather than risks of paraphrasing or getting lost = ownership increased
- Able to understand how issues and opportunities impact one another and thus capture the systemic nature of the focal issue – better systemic understanding
- Ability to identify clusters - content oriented themes - helping participants navigate the material and ensuring that complexity is managed, not simply reduced.
- Ability to ask why issues matter enabling participants to reflect on values that drive them rather than responding to provided values (bounded list) or those that are currently topical and given lip service to -> Able to tease out values 'in action' – those that are acted upon and drive behaviour
- Able to prioritise themes, issues, values and opportunities to determine degree of consensus as well as priorities
- Development of a network of issues, opportunities and values (through chains of argument) which can be analysed for key properties such as dominant issues/opportunities, feedback dynamics etc and can feed into more quantitative models. A series of workshops can be reviewed and analysed to determine intra and inter levels of homogeneity etc.
- Able to involve those that are geographically dispersed (no costs - time or $$)
- Enables participants to gain a deeper more nuanced understanding of the topic being focused upon and increased ownership for outcomes

Disadvantages

- Complex maps which are challenging to read by those not involved in generating them
- An array of issues to tackle when considering MMS (or whichever topic is focused upon) which may feel overwhelming and may raise expectations in the minds of those involved
- Non quantifiable data but the map’s structure can be used to develop quantifiable models (e.g. MCDM, SD simulations etc.)
- less building of a team/a shared sense of commitment
- relies on a good internet access speed

Input requirements

- 3-3.5 hours participant time x # participants
- Software requirements
- Facilitator time (including time expended for set up, managing the workshop, analysing the data, producing the report)
- Trained facilitators

Outputs

- Policy makers are provided with a clear sense of the priorities, concerns and aspirations of particular communities/cohorts and how these impact one another – thus able to make more robust and sustainable decision making
- Policy makers/local government have clarity re competing values/aspirations of stakeholder groups - enabling increased 'buy-in' and facilitating communication
- Policy makers are able to use the information to feed into semi-quantitative and quantitative models (through provision of structure) for further analysis
- Oil and Gas are able to make decisions about decommissioning which take account of community views (both issues and opportunities)
- Regulators are provided with a mandate to work with stakeholder groups to develop effective and evidence based (informed by identified research needs) regulations reflecting the diversity of values
- Recreational and Commercial fishing decision makers are given insight into the competing uses
- Participants gain a deeper understanding of the topic, allowing them to understand more effectively their own views and seeing them in the context of others thus building shared understanding, alignment of view and a platform for action
- All are made aware of the multiple different stakeholder cohorts and the variations of issues, opportunities and values both within and across cohorts

Examples

- See Sections 'Social Value Group', in Harvey et al (2021) "Enhancing the Understanding of the Value Provided to Fisheries by Man-made Aquatic Structures", FRDC project No 2018-053.

Literature Examples

- Not currently available.

Face to face manual mapping-based focus groups

Advantages

- Able to capture a wide range of issues and opportunities through participants writing views on post-it notes allowing for simultaneous contribution = highly productive use of time and more even distribution of contribution.
- Reduce conformity pressures through a degree of anonymity allowing for increased openness and thus representativeness of view. Avoiding conformance pressures can be ensured through good facilitation – by, for example, ensuring silent time for all to write down their thoughts, providing participants with identical pens to avoid easily distinguishing authors.
- Capture participant's contributions accurately rather than risks of paraphrasing or getting lost = ownership increased
- Able to understand how issues and opportunities impact one another and thus capture the systemic nature of the focal issue
- Ability to identify clusters - content oriented themes - helping participants navigate the material and ensuring that complexity is managed, not simply reduced.
- Able to tease out values 'in action' - through asking why issues matter, participants reflected on values that drive them rathe rather than espoused values
- Able to prioritise themes, issues, values and opportunities to determine degree of consensus as well as priorities
- Development of a network of issues, opportunities and values (through chains of argument) which can be analysed for key properties such as dominant issues/opportunities, feedback dynamics etc. and can feed into more quantitative models
- Able to involve those that are geographically dispersed – cutting out travel costs in terms of both participant time or $$ expended.
- Enables participants to gain a deeper more nuanced understanding of the topic being focused upon and increased ownership for outcomes
- Familiar and easy to set up approach

Disadvantages

- Complex maps which are challenging to read by those not involved in generating them
- An array of issues to tackle when considering MMS (or whichever topic is focused upon) which may feel overwhelming and may raise expectations in the minds of those involved
- Non quantifiable data but the map's structure can be used to develop quantifiable models (e.g. MCDM, SD simulations etc.)
- Either needs to be captured into a software package or analysed manually which is challenging
- Requires strong facilitation to avoid dominant members hijacking the meeting

Input requirements

- 3-3.5 hours participant time x # participants
- Appropriate Venue
- Facilitator time (including time expended for set up, managing the workshop, analysing the data, producing the report)
- Trained facilitators

Outputs

- Policy makers are provided with a clear sense of the priorities, concerns and aspirations of particular communities/cohorts and how these impact one another – thus able to make more robust and sustainable decision making
- Policy makers/local government have clarity re competing values/aspirations of stakeholder groups - enabling increased 'buy-in' and facilitating communication
- Policy makers are able to use the information to feed into semi-quantitative and quantitative models (through provision of structure) for further analysis
- Oil and Gas are able to make decisions about decommissioning which take account of community views (both issues and opportunities)
- Regulators are provided with a mandate to work with stakeholder groups to develop effective and evidence based (informed by identified research needs) regulations reflecting the diversity of values
- Recreational and Commercial fishing decision makers are given insight into the competing uses
- Participants gain a deeper understanding of the topic, allowing them to understand more effectively their own views and seeing them in the context of others thus building shared understanding, alignment of view and a platform for action
- All are made aware of the multiple different stakeholder cohorts and the variations of issues, opportunities and values both within and across cohorts
- NOTE: to fully leverage the material capturing the data into a software package would facilitate usage

Literature examples

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Brainstorming approaches

Advantages

- Familiarity with the process of brainstorming – natural to all participants
- Easy to set up and manage
- (when using software) anonymity and speed of capture

Disadvantages

- Unstructured data making it hard to understand how to use this information for decision making.
- Lack of clarity in terms of meaning as the language used can be ambiguous
- Software access and participant devices required

Input requirements

- 3-3.5 hours participant time x # participants
- Appropriate Venue
- Facilitator time (including time expended for set up, managing the workshop, analysing the data, producing the report)
- Trained facilitators

Outputs

- Lists or clusters of material that can be used to inform decision making

Literature Examples

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Appendix 1

Table A1 Summary of the advantages and limitations of different data collection approaches

	In-person survey	Online survey	Stakeholder Interviews	Workshops/ forums
To what extent will the data...				
Represent all stakeholders				
Provide depth of understanding				
Uncover system interrelationships (systemicity)				
Is the data…				
Quantifiable				
Context sensitive				
Does the approach…..				
Engage multiple stakeholder groups (direct)				
Engage multiple stakeholder groups (indirect)				
Increase the awareness/understanding of those that participate				
Require significant resource investment to implement				

Legend – green = considerable contribution, orange = moderate contribute and red = low to no contribution

Notes:

1. Surveys can include both quantitative and qualitative questions. Ratings assigned based on predominantly quantitative survey questions that allow quick completion.
2. Note, that 'literature review' is not included in the table, as the availability of published information on any chosen topic will differ by context and over time. **Click** on the column heading to see further information on that approach.
3. In principle an in-person survey could provide the same outcomes as an online survey if resources are available to achieve the same number and same representativeness of respondents, but this is likely to be prohibitively expensive in many circumstances.
4. The administrative ease of online surveys is conditional upon the availability of representative panels of online respondents to draw from, and an established infrastructure to distribute surveys.