



Full length article



## A framework for the integrated assessment of social and economic values associated with man-made marine structures

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### ARTICLE INFO

#### Keywords:

Marine spatial planning  
Offshore artificial structures  
Stakeholder values  
Social license to operate

### ABSTRACT

Man-made marine structures (MMS) are increasingly prevalent in the marine environment, reflecting the growth and diversity of economic and recreational activities in both onshore and offshore settings. The presence of MMS presents opportunities and conflicts for marine planners, particularly in relation to reconciling competing stakeholder interests arising from their placement and long-term fate, including decommissioning and/or removal. This necessitates the development of an integrated framework which encapsulates the complexity of social and economic values and perceptions held by differing stakeholders. Through research conducted with MMS stakeholders in Australia, we present the first framework of this type which identifies three principal categories of socio-economic values and explores the inter-relationships between these groupings. The research further underlines the pivotal significance of rules and norms which impact across all three categories. These findings will assist planners in understanding the preferences of relevant marine stakeholders in order to enhance benefits and minimise conflicts related to MMS.

### 1. Introduction

The term man-made marine structures (MMS) refers to any artificial structures situated in the marine environment, encompassing shipwrecks, artificial reefs, aquaculture facilities, sea defences, structures associated with harbours, jetties, marine navigation markers and oil and gas infrastructure such as platforms, wellheads, and pipelines [20]. The total coverage of MMS is estimated to rise from 32,000 km<sup>2</sup> in 2018 to 39,400 km<sup>2</sup> by 2028 [7]. This will be equivalent in area to 2.4% of the world's maritime exclusive economic zones, reflecting the expansion of the 'blue economy' including sectors such as offshore energy and aquaculture. The presence of MMS provides a hard substrate for colonisation by marine species, enabling a complex habitat consisting of multiple trophic levels to become established within decadal timescales [10]. These enhanced areas of marine biodiversity offer opportunities to a wide range of stakeholders, with different types of MMS being prioritised for different purposes which may or may not be complementary [19]. For example, recreational fishers are known to use jetties, groynes, breakwaters and artificial reefs [4,12,26]. Recreational and commercial

fishers target decommissioned oil and gas infrastructure including platforms and pipelines [5,9,28]. Jetties, shipwrecks, and decommissioned oil and gas infrastructure are also utilised by recreational scuba divers [29,30]. Moreover, oil and gas platforms are regarded as essential fish habitat in some countries [17], or to hold conservation significance in areas where marine life is depleted [13]. However, these considerations must be balanced against the potential adverse impacts of artificial marine structures, particularly their potential to act as a vector facilitating the spread of invasive species [3,8] and the long term release of contaminants from decommissioned oil and gas structures [32]. In addition, realising the long-term benefits of MMS also depends on effective management of associated human activities. A recent survey indicated that almost 80% of artificial reefs in the Caribbean are at risk of over-exploitation, demonstrating the need for integration of MMS into broader management plans [18].

Values represent the expression of preferences, beliefs and attitudes within individuals and communities arising from the interaction of internal factors such as morals, needs or desires and external factors such as ethical systems, cultural norms or institutional rules [31]. An

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<https://doi.org/10.1016/j.marpol.2023.105612>

Received 11 October 2022; Received in revised form 30 March 2023; Accepted 1 April 2023

Available online 5 April 2023

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individual’s value system therefore comprises a complex and dynamic network of influences. In natural resource management, categorisation and quantification of values necessitates the integration of diverse disciplinary approaches ranging from sociology and psychology through to economics and ecology. This is reflected in the 2005 Millennium Ecosystem Assessment (MEA) classification of ecosystem services into provisioning, regulating, supporting and cultural services, each of which is associated with specific methodological frameworks and techniques.

The biodiversity outcomes arising from the presence of MMS are associated with a range of provisioning services (e.g. enhanced fish diversity and abundance) and cultural services (e.g. recreation and tourism) which can be described through various social and economic values. Stakeholders may hold a variety of complementary and competing values associated with their use of MMS which must be recognised by marine planners with responsibility for decisions regarding the placement, use and long-term fate of MMS. However, there is a lack of detailed information concerning the social and economic values held by MMS users [11,25]. This is becoming increasingly significant for marine spatial planners in areas including the decommissioning of redundant oil and gas facilities and meeting demands for increased offshore wind generation [22,27].

This paper reports the process and high level outcomes from an interdisciplinary research project investigating the values associated with MMS in Western Australia [15]. An integrated framework of stakeholders’ social and economic values relating to MMS is presented and its application to specific case studies of MMS in the region are discussed. This framework will assist marine planners through illustrating the diversity and inter-connected nature of stakeholder values and realising the benefits of integrating these into decision-making processes.

**2. Methods**

Primary data was collected through online surveys targeting MMS users and a series of focus group workshops involving specific stakeholder groups. Secondary data was also collected relating to economic use values. All of these are described in turn below. Primary data collection methods were approved by the Curtin University Human Ethics Committee (HRE2019–0465).

A suite of integrated online surveys exploring social and economic values within specific user groups consisting of open-ended, closed and Likert scale questions was constructed in Qualtrics. The structure of this

survey is summarised in Fig. 1 with further details being provided in Figs. S1 and S2 in the Supplementary Materials. Following some brief background questions, each respondent was asked to self-assign to one specific user group. These categories were defined in the survey as recreational fishers; divers (including divers, snorkelers and free divers not engaging in extractive activities); commercial fishers and ‘others’. The survey then directed recreational fishers and diver respondents to specific questions relating to their fishing or diving experience, preferred mode of diving or fishing and the importance of this activity. All respondents were then asked to identify the type of MMS structure they had used in the last 12 months and the location of their preferred MMS. The survey then asked a series of questions relating to respondents’ social and economic values and perceptions associated with MMS. These values and perceptions were identified from an earlier comprehensive literature review [11] and were explored through a series of five point Likert scale questions comprising ‘strongly agree’, ‘somewhat agree’, ‘neither agree nor disagree’, ‘somewhat disagree’ and ‘strongly disagree’ (values) and ‘very important’, ‘somewhat important’, ‘neutral’, ‘not particularly important’ and ‘not at all important’ (perceptions). A constraint of close-ended surveys arises when seeking to cover a complex issue through the use of short (to reduce time constraints), simple (understood by a diverse audience) and clear (no ambiguity in terms) questions. To address these issues, the questions relating to values and perceptions were specifically designed to the self-identified user group. In addition, respondents were then given the opportunity to describe via open-ended responses the benefits and limitations of MMS and preferred options for decommissioning offshore oil and gas facilities.

The survey then invited recreational fishers and divers to complete an additional series of questions exploring the economic use value of MMS. This component explored the spatial patterns of respondents’ recreational fishing or diving in the last 12 months around four MMS sites in Western Australia illustrated in Fig. 2 and Figs. S3-S6 in the Supplementary Materials. Respondents were asked information including which MMS sites were visited and distance travelled from the shore, enabling the estimation of economic use values through a random utility travel cost model as used widely in the literature [23,33].

Visitors to two iconic recreation sites and commercial fishers followed a slightly different path through the survey, with sets of tailored questions before being passed into the ‘use, perceptions and social values’ component of the survey. The Navy Pier at Exmouth is restricted for pre-booked diving activity and the Busselton Jetty is a popular

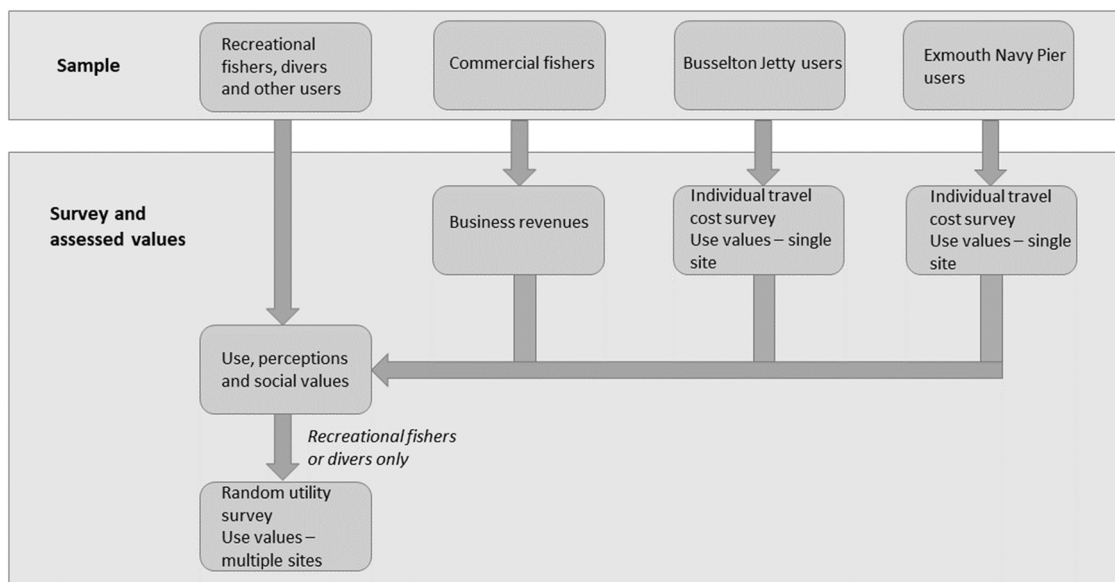
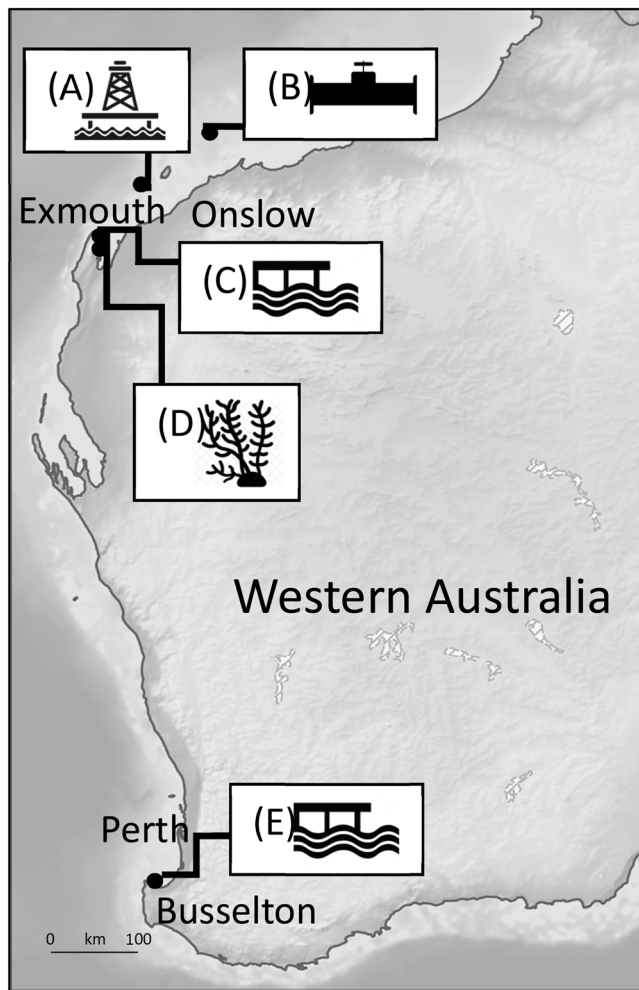


Fig. 1. Online survey structure showing users and data collected.



**Fig. 2.** Locations of MMS sites used in online survey: (A) Thevenard oil and gas infrastructure (25 km offshore); (B) Echo Yodel Pipeline (150 km offshore); (C) Exmouth Navy Pier; (D) Exmouth Artificial Reef (7 km offshore); (E) Busselton Jetty.

destination for recreational fishing, diving and other activities. Users of these sites were first asked for information relating to the number of visits in the last 12 months and associated travel costs to estimate the economic use value that people hold for visiting these structures. Once they had completed these short surveys, they were directed into the social values component of the survey. Commercial fishers were asked specific questions relating to the commercial value of their catch associated with fishing in and around MMS.

The online survey was available for a period of four months (November 2019 – March 2020) and was publicised to all MMS users via online stakeholder group newsletters and advertisements placed in recreational fishing outlets, dive shops and at specific popular MMS sites throughout Western Australia. Commercial fishers were recruited through the assistance of the peak body (Western Australian Fishing Industry Council). As an extra incentive, respondents were eligible to enter a draw for three cash prizes of AUD750 each upon survey completion.

In parallel with the online surveys, the team conducted a series of focus group workshops to gain a more nuanced and systemic appreciation of values and perceptions and their homogeneity or heterogeneity through an interactive discussion involving representatives of specific stakeholder groups. The workshops comprised a mix of face to face and online meetings due to restrictions being imposed by COVID-19 during data collection (October 2019 – August 2020). Eleven workshops each

lasting around three hours were held involving a total of 64 representatives from the federal and state government, the private sector, academic researchers, commercial and recreational fishers, oil and gas companies and non-governmental organisations. Participants were recruited using personal contacts and recommendations from peak bodies representing stakeholder groups. Whilst the majority of the participants were from Western Australia, representatives from other states (New South Wales, Queensland and Victoria) and territories (Canberra and the Northern Territory) were also present. We acknowledge that some stakeholder groups, notably those representing Indigenous perspectives, are not included, which reflects time and resource constraints in this research.

The workshops were run using a Group Support System (Strategy-Finder™) which enables each participant to interact anonymously on a computer terminal and simultaneously view the contributions of others, with only the facilitator being able to identify each participant's contribution. A summary of this procedure is given below (Fig. 3) with further details and examples being provided in Ackermann [1]. Each workshop commenced with participants entering their perceptions of issues and opportunities associated with MMS and then expanding on these as they viewed others' contributions. The facilitator continuously clustered these into emerging themes, inviting participants to view these and comment. The facilitator then structured the issues and opportunities within each theme into a network depicting causal relationships and cross-thematic linkages, again inviting comment and contributions from all participants. These emergent clusters were then examined by all participants to identify values associated with each cluster, using the logic that if participants perceived an issue or opportunity then that was because it implicitly affected something which was valued. Each workshop concluded with a quantitative rating of the dominant issues by all participants, enabling exploration of consensus within and between workshops.

Finally, a desktop analysis was also undertaken of the value of the Exmouth Artificial Reef in terms of the increase in value to recreational fishers. This used the approach outlined by McLeod and Lindner [21] utilising data therein relating to estimates of changes in visitation rates, quality of fishing experience and estimates of the value per fishing trip.

### 3. Results and discussion

This section will present a summary of the social and economic values derived through the online survey and workshop groups. More detailed analyses of specific stakeholder group values and perceptions emanating from this research is available in Harvey et al. [15] and will be explored in separate publications. In addition, a practical guidebook [16] was produced as part of this research which provides support to managers in selecting appropriate methods to evaluate social and economic values of MMS.

#### 3.1. Results

The online survey yielded a total of 550 responses, of which 109 were incomplete and removed from further analysis. Within the remaining 441 full responses, recreational fishers comprised the largest (n = 309; 70.1%) user group, followed by divers (n = 81; 18.4%) and commercial fishers (n = 23; 5.2%), with the remaining 'others' (n = 28; 6.3%) comprising representatives of tourism organisations, academics, conservation organisations and government employees. The relatively small proportion of divers may reflect the fact that, whilst varied efforts to maximise recruitment via publicity and financial incentives were undertaken, there is no representative peak body for divers that could be utilised as a central point of information dissemination which will tend to inhibit wider participation in any form of online survey. Furthermore, disruptions in recreational activity due to Covid-19 restrictions occurred during the sampling period, which could have restricted survey awareness and participation. The quantity of commercial fisher respondents

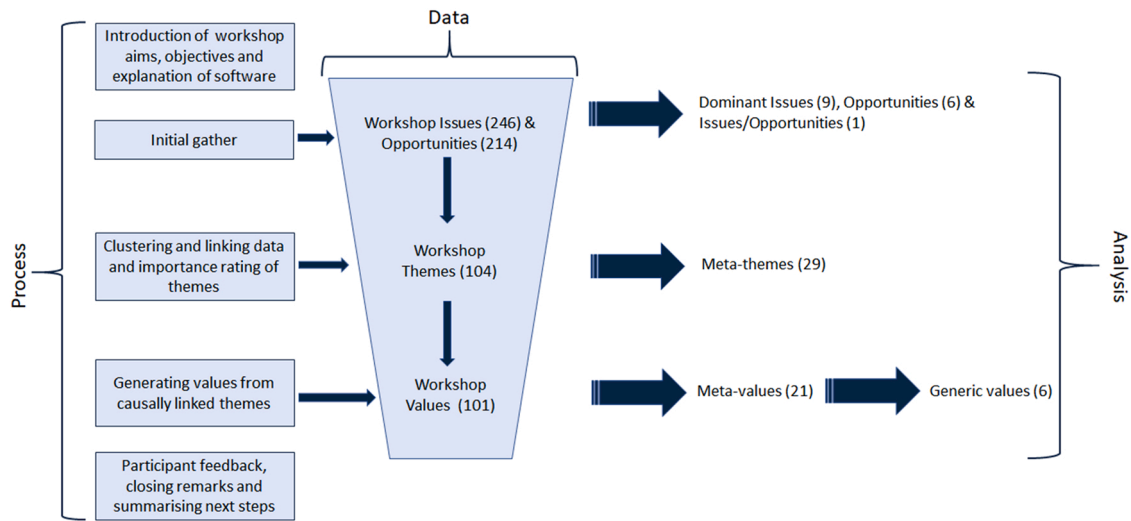


Fig. 3. Summary of workshop processes.

will partially reflect the fact that they are a smaller stakeholder group and may be less likely to be incentivised via a financial inducement. However, the existence of a peak body enabled recruitment and participation of commercial fishers through the stakeholder workshop process described above.

Figs. 4 and 5 present the average Likert scores including 95% error bars for the importance of values and perceptions identified via the literature review disaggregated by stakeholder group. Scores of + 2 and - 2 equate to 'strongly agree' and 'strongly disagree' respectively in Fig. 4, whilst scores of + 2 and - 2 correspond to 'extremely important' and 'not at all important' respectively in Fig. 5. As the surveys were tailored to individual stakeholder groups, an absence of response indicates that a question was not appropriate for that specific stakeholder group (eg 'memories and souvenirs' was not an applicable value for inclusion in the survey of commercial fishers using MMS).

Fig. 4 indicates that most MMS values identified in the literature were viewed positively by all stakeholder groups, particularly those relating to the contributions of MMS to ecosystem health, community identity and the local economy. Key differences between user groups

included the importance of unregulated access (i.e. open access to all) to the recreational fishers and divers versus commercial fishers and 'others'. Similarly, perceptions of MMS were predominantly positive (Fig. 5). Recreational fishers and divers were most likely to perceive that MMS increased fish populations and contributed to local tourism and employment opportunities. Furthermore, there was a weaker perception that MMS are sites of conflict between user groups. Commercial fishers and 'others' generally held more ambivalent perceptions than the other groups, with commercial fishers perceiving little benefit of MMS in relation to abundance of their target species, although this was not reflected in a perceived negative impact on their fishing activities. It should be borne in mind that this final question was only directed at commercial fishers, as indicated in the Methods section.

The group workshops resulted in a total of 104 values being identified, underlining the potential breadth of stakeholder values in relation to MMS. Many of these values were similar in content and/or meaning, enabling them to be combined into 21 meta-values and six generic values as illustrated in Fig. 6. It is also worth noting that each of the six generic values was derived from multiple stakeholder workshops,

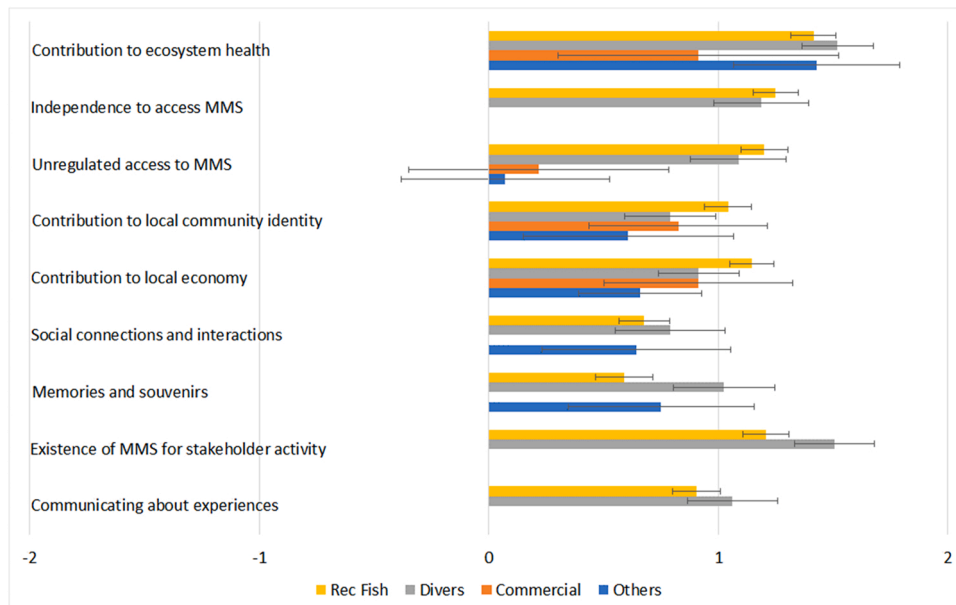


Fig. 4. Average Likert scale scores including 95% error bars for values by stakeholder group.

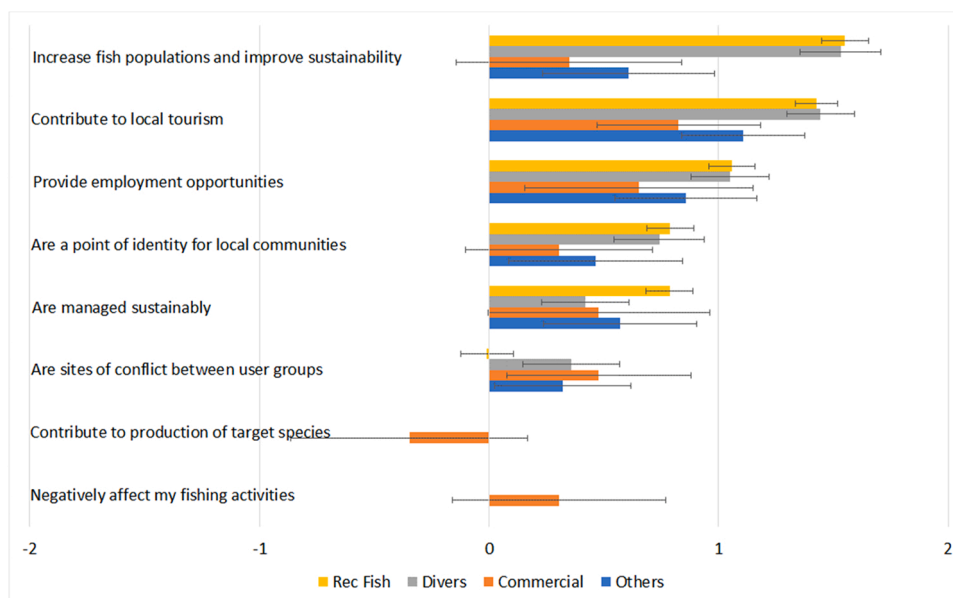


Fig. 5. Average Likert scale scores including 95% error bars for perceptions by stakeholder group.

indicating that these held broad support across stakeholder cohorts. The only exception to this rule was the ‘effectively designed MMS’ generic value, which reflected cost concerns aired by representatives from the oil and gas sector.

The economic analysis of individual MMS sites revealed the additional value, measured as consumer surplus to fishers, was AUD114,000–267,000 per year for the Exmouth Artificial Reef and AUD409,000 per year for the Exmouth Navy Pier. Busselton Jetty, which has much higher visitation rates (approximately 0.5 million people annually), yielded a correspondingly higher value of around AUD19M per year.

The random utility models of site choice allow an estimation of the value associated with a number of MMS in the different regions, including artificial reefs and shipwrecks. In the Geographe Bay region, there is no estimate of aggregate visitation, so aggregate values cannot be identified, but our modelling indicates values per trip ranging from AUD9.6 per trip to an existing jetty to AUD11.9 per trip to additional jetties for fishers and AUD18 to an existing shipwreck dive to AUD26 for additional dive sites.

### 3.2. Integrated framework

In this section, the values and perceptions derived from the online survey, workshops and economic analysis are analysed to derive an integrated framework which encompasses all values and captures the interactions between them. Three overarching categories are identified which collectively represent all values. These are:

1. Use values. These are defined as the values that arise from the direct use of MMS and can be interpreted as economic direct use values and social values held by the individual reflecting their interaction with MMS.
2. Community values. These relate to a broader scale and can be interpreted as economic indirect use values and social values reflecting attributes gained by users arising from the presence of MMS.
3. Environmental values. These are associated with the quality of the marine environment as this pertains to the presence of MMS. In economic terms, those values are existence or non-use values held by the general public, whilst social values reflect the significance of these environmental qualities to an individual.

Fig. 7 depicts these value categories as three circles. Within each value category, there is an overarching value represented by larger nodes which are hereafter referred to as ‘end state values’. Thus, ‘community benefits’ is the end state value in the ‘community values’ category, ‘user wellbeing’ is the end state value in the ‘use values’ category and ‘condition of marine environment’ is the end state value in the ‘environmental values’ category. Each end state value is influenced by other factors or values, which are represented by links to nodes both within and across the three categories. Several values lie outside of this main categorisation. ‘Social license to operate’ and ‘regulations’ were grouped into a sub-category called ‘rules and norms’, whilst ‘design of MMS’ is a stand-alone value.

The coloured segments around each node denote where each value was detected through the research activities. These are colour coded, hence blue signifies a value derived through the online social values and perceptions survey, green denotes a value identified through the economic analysis and orange represents a value identified through the focus group workshops. Where all three coloured segments appear it can be reasonably assumed that there is triangulation across data sources and thus an increased significance may be attached to that value.

It is important to note that absence of colour in Fig. 7 does not indicate whether a certain node definitely does not have economic or social values attached to it, but rather reflects the outcomes of this research project. As an example, it is possible to quantify the impact that invasive species on MMS have on economic existence values, but this has not been identified here. It should also be borne in mind that this categorisation process may obscure differing stakeholders’ interpretations and understandings of values. For example, ‘safety’ is a highly subjective value, reflecting an individual’s perception of what constitutes personal or collective safety (e.g. proximity of MMS to shore, visibility of MMS, behaviour of individuals in and around MMS and so on). Thus, each value should be understood as including potentially different emphases or characteristics, whilst the importance attached to each value will vary within and between stakeholder groups. With that caveat in mind, the discussion will now examine each of the three main categories in turn.

#### 3.2.1. Use values

‘User wellbeing’ is the end state value in this category. This is influenced by individual use (including experiences of using MMS) and the benefits of interacting with other users. These in turn are conditioned mainly by access, which is a complex value composed of elements

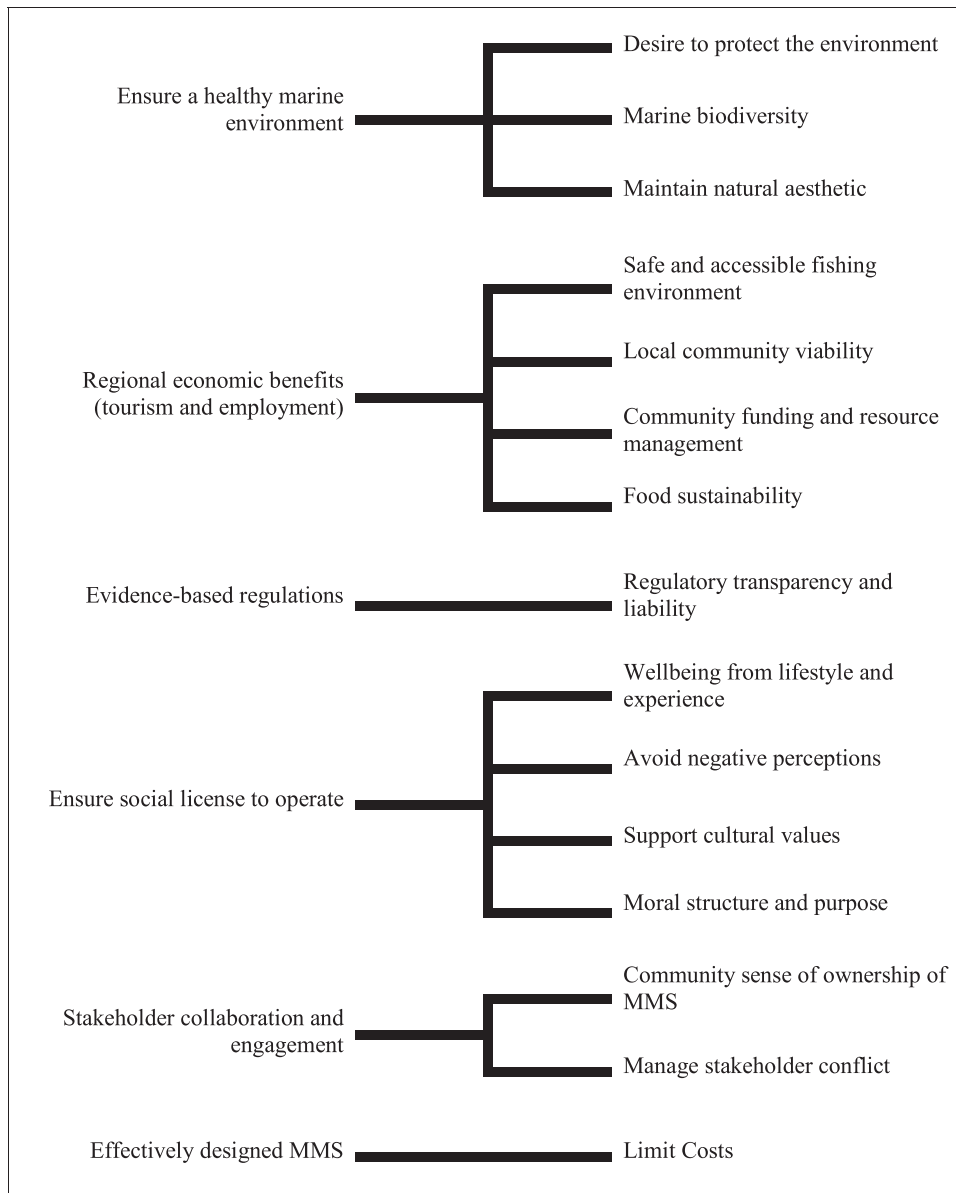


Fig. 6. Generic values (6) and meta-values (21) derived from stakeholder group workshops.

including the physical location of MMS, travel costs, personal safety considerations and any regulations defining rights of access for specific user groups. Use is also related to values in other categories, including job creation and business revenues and the condition of the marine environment. Accessibility was particularly important to recreational fishers and divers, who valued the enhanced opportunities for greater involvement and engagement with the marine environment. Further depth to the notion of user wellbeing was provided by focus group outcomes, which noted the cultural importance of MMS through fulfilling traditional lifestyle habits such as ‘catching a fish for dinner’ and the aesthetics of the MMS.

However, it is important to consider how cumulative policy decisions may impact on these professed values. Whilst the economic data indicated an increase in consumer surplus value to both recreational fishers and divers as more sites are available, they did not predict how the values per additional MMS may change when creating numerous MMS in a region. It is likely that there is a saturation at some point and indeed, the social focus groups revealed that there was concern that whilst one or two MMS might be acceptable, a cumulative build-up of MMS could be perceived as losing the ‘authenticity’ associated with fishing and

diving over natural sites. Results from the social values survey also highlighted issues of overcrowding and inappropriate behaviour by some users impacting the enjoyment and well-being of others. Hence, MMS are also perceived as potential sites of conflict between different users. As an example, divers believe the values of diving at MMS decrease in the presence of recreational fishers due to the prevalence of lost fishing equipment and rubbish on the seafloor and the behaviour of fishers. Similarly, the value that recreational fishers place on MMS decreases if commercial fishers have access. Commercial fishers want certainty over access to MMS, particularly if they were to invest in them, and stressed the need to recognise and reconcile different priorities within the sector (e.g. aquaculture versus line fishing). This result was supported by findings from the random utility model component of the survey which showed that recreational fishers attach no significant value to shipwrecks for which they have no access. Conflict also emerged as a theme from the workshops with conflict possibly arising from the allocation or designation of MMS for specific user groups.

Considering Fig. 7, it is evident that regulations and MMS design are key drivers of values within the use values category. Regulations exert an influence on this flow of use values through determining how and

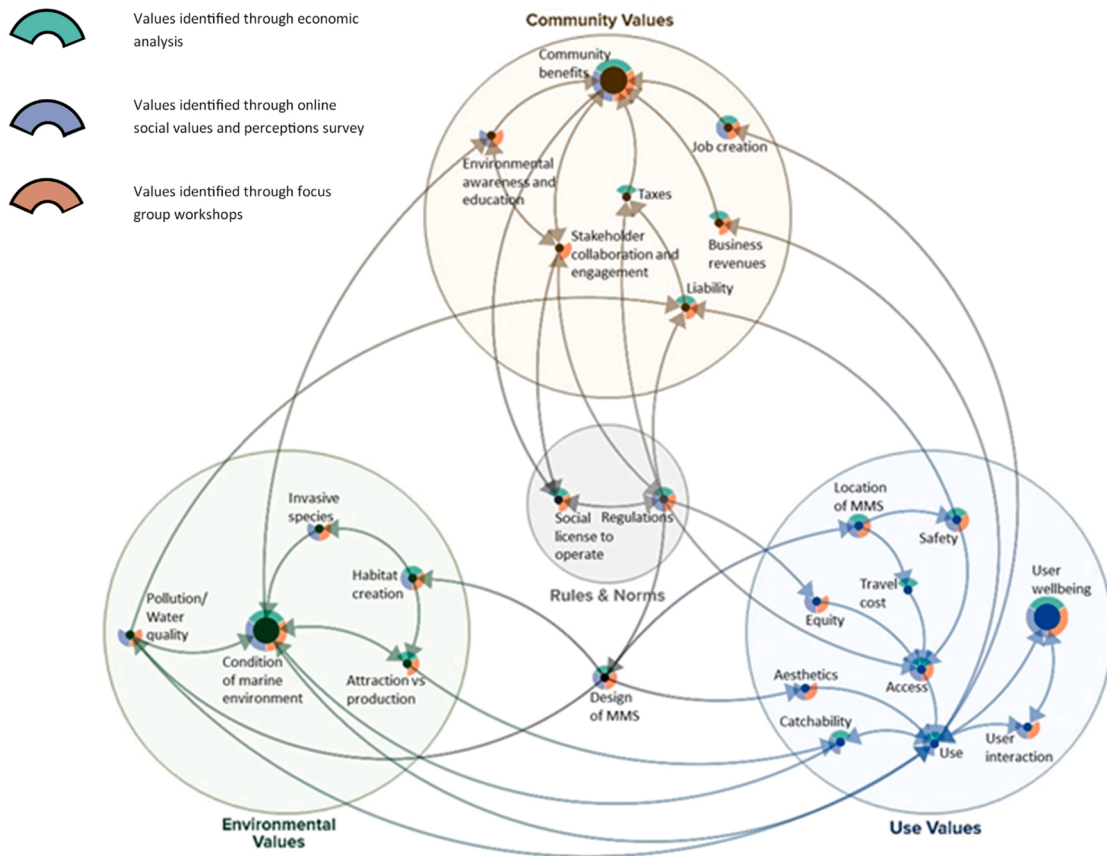


Fig. 7. Integrated framework depicting social and economic values of MMS.

when users can access MMS, whilst MMS design determines location, type of construction and the capacity of the MMS to support multiple user groups. This raises the issue of resource allocation and sharing and implies that the purpose of the installation of an MMS needs to be well defined, which may lead to specific types of MMS being allocated to specific stakeholders/user groups at some locations. To some extent, this already occurs in Western Australia with recreational fishing on shipwrecks such as the HMAS Swan and HMAS Perth banned so that these wrecks are for the use of recreational scuba divers only. Resource allocation can result in better outcomes for all users which will ultimately lead to greater user wellbeing being derived from MMS. It was noted in the group value workshops that more research into the justification for MMS in terms of designated users was an important priority.

### 3.2.2. Community values

‘Community benefits’ is the end state value in this category, with job creation being the only related value highlighted by all three research streams. Job creation evidently has many economic and social co-benefits which would be desired by stakeholders, including direct and indirect employment opportunities, community stability and local identity. Business revenues and taxation are also important values generating community benefits alongside environmental awareness and education. Community benefits are directly related to values outside of this category including social license to operate, whilst job creation is influenced by MMS usage as represented in the use values category.

Business revenues and the creation of jobs are flow-on effects of the direct use of MMS. For example, we estimated that people that dive the Exmouth Navy Pier spend about AUD205 for one day’s diving (AUD615,000 annually). We also found that the expenditures related to the Exmouth Navy Pier made up a substantial part of business revenues and employment for the operating dive company. For Busselton Jetty, the expenditure was estimated at AUD12 per person per visit or annual

expenditure of AUD 6.4 million. Using boat launches and fisher expenditure data, our modelling indicates that the Exmouth Artificial Reef could generate between AUD155,000–1.05 M for the local economy through recreational fishing alone. However, it must be noted that these gains in regional income could be associated with reductions elsewhere if individuals are choosing to concentrate their effort around the artificial reef.

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

Commercial fishers can also benefit economically from MMS. For example, commercial trap fishers have been documented fishing near offshore oil and gas structures [5]. Another example of commercial fishing and aquaculture benefitting from MMS is the design and deployment of purpose-built artificial reefs to allow in-water sea ranching [14]. Some commercial fishers in the workshops believed that the construction and deployment of purpose-built artificial reefs were one mechanism available to them for increasing their profitability. Challenges to pursuing this option for enhancing fishing and profits were the current legislation for deployment and installation of artificial reefs

and obtaining exclusive access rights – touching again on the transparency of regulation value. In addition, the online survey found that commercial fishers and other stakeholders were less inclined to agree that MMS deliver environmental benefits although the workshops did see environmental values being subscribed to, but with less weight than economic criteria. This underlies a need to demonstrate the environmental benefits of MMS if policy makers are seeking to gain widespread community support.

One challenge highlighted by the focus groups and online surveys was the question of who assumed the long-term liability for MMS. The focus groups revealed that there is a perception by some stakeholders that oil and gas companies wanted to ‘dump’ their rubbish on the sea-floor under the guise of a ‘rigs-to-reefs’ program and transfer liability to the government. This perception led to one of the most frequent concerns raised which was who was responsible for the maintenance of MMS and the liability and costs of removal at the end of its life, or for the costs of clean up if an unforeseen event occurred. This was particularly relevant to discussions around the need to reduce regulatory uncertainty by having clear and consistently applied guidelines both for decommissioning and the installation of new structures.

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

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

### 3.2.3. Environmental values

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

Man-made marine structures often have unique assemblages of marine organisms, and in the case of some artificial reefs, jetties and piers, oil and gas platforms and pipelines the biomass of fish exceeds nearby marine habitats [6,24]. In part, this is because some of these structures are not fished, but also because the sometimes vertical and complex engineering of the structures create a number of different habitats and ecological niches for organisms to occupy. Habitat creation was frequently cited as an important value and driver in the online survey of social values, whilst focus group work revealed a broad range of environmental benefits associated with MMS including increasing or

improving local fish stocks, biodiversity and overall ecosystem health.

There was also a belief that MMS benefited the marine environment by diverting recreational fishing and other pressures away from natural habitats – although care had to be taken as the provision of well sited MMS could result in over-fishing (both at the site of the MMS and the surrounding area as fish moved from one location to another). Whilst the social and economic benefits arising from the impact of MMS on the marine environment were noted across all stakeholders, there were clear differences in nuance. For some focus group respondents, the emphasis was on protecting the environment whilst for others it centred on rebuilding the environment, which may reflect whether respondents had a pristine or damaged marine environment in mind.

In addition, in both the online survey and workshops, stakeholders raised issues and concerns about the installation of MMS including potential pollution (whether that be from the gradual disintegration of the structure or the aesthetics of visual pollution) and a degradation of the marine environment due to MMS. It was also noted that they could become stepping stones for the spread of invasive marine species suggesting careful management and design would be needed. Focus group participants were also concerned that excessive use can lead to detrimental environmental impacts such as pollution and a reduction in the quality of the marine environment due to over-fishing. There was a concern from focus group participants that current policy and legislation was unable to reflect what stakeholders wanted and needed. This was particularly the case for decommissioning of oil and gas infrastructure whereby options were supported on the premise that decommissioning was evidence based, addressed community and regulator concerns about pollution, habitat degradation, and invasive marine species and benefitted a broad range of stakeholders, including scuba diving and conservation.

### 3.2.4. Rules and norms

As noted previously, it was necessary to include a small subcategory entitled ‘Rules and Norms’ to reflect the importance attached to regulations and a social license to operate. These values are closely related and underline the importance of regulations that were seen as transparent, consistent and evidence-based. A failure to adhere to these values would negatively impact all three end state values in the other categories. The focus group work revealed that such a failure would manifest through a lack of clarity in policy, incidents associated with MMS acting as hazards to individual or commercial activities or evidence of contamination arising from MMS degradation or disintegration. The linkage between regulations and design of MMS in Fig. 7 reflects these opinions.

## 4. Conclusion

The placement of man-made structures in the marine environment presents new challenges in understanding how the relationship that people form with the places around them evolve and how a ‘sense of place’ ([2] p27) can develop at the individual and stakeholder group level. Understanding the values that underpin these relationships is an essential element in marine spatial planning and one that assumes greater significance as the imprint of human activity is increasingly visible in the marine environment. This research has described the nature, strength and breadth of social and economic values held by users of MMS and the relationships between these. Whilst some values are intrinsically related to personal experience of using MMS (principally user wellbeing and associated values), the benefits arising to the wider community from their presence, both social and economic, are highly valued. Furthermore, most users are united in valuing the potential contribution of MMS towards maintaining a healthy marine environment. It is recommended that decisions regarding the placement and use of MMS take particular account of these individual and collective values and perceptions which may be manifest to varying extents between and within stakeholder groups.



However, there are substantial differences in the preferences of who can access and how to best use MMS among stakeholder groups. In particular, values held by stakeholder groups that potentially restrict another group's activities (such as extractive activities, non-extractive activities and conservation) can bring about conflict between stakeholder groups. Moreover, all values are contingent upon a regulatory environment which is transparent, consistent and evidence-based. This has yet to transpire in the context of MMS, with governments worldwide adopting contrasting and continually evolving approaches to regulation. Future research could therefore focus upon how stakeholder values and perceptions towards MMS vary under different regulatory regimes in order to identify a framework which minimises conflicts and optimises the benefits of MMS to all stakeholders.

## Data availability

The authors do not have permission to share data.

## Acknowledgements

The authors would like to acknowledge funding from the Australian Fisheries Research and Development Corporation (FRDC-2018–53) and Chevron which enabled this research to be conducted.

## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.marpol.2023.105612](https://doi.org/10.1016/j.marpol.2023.105612).

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