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Research article

Identifying conflict potential in a coastal and marine environment using participatory mapping

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ABSTRACT

Planning for coastal and marine environments is often characterized by conflict over current and proposed uses. Marine spatial planning has been proposed as a way forward, however, social data are often missing impeding decision-making. Participatory mapping, a technique useful for providing social data and predict conflict potential, is being used in an increasing number of terrestrial applications to inform planning, but has been little used in the marine realm. This study collected social data for an extensive coastline in northwestern Australia via 167 in-depth face-to-face interviews including participant mapping of place values. From the transcribed interviews and digitized maps, we inductively identified 17 values, with biodiversity, the physical landscape, and Aboriginal culture being most valued. To spatially identify conflict potential, values were classified in matrices as consumptive or non-consumptive with the former assumed to be less compatible with other values. Pairwise comparisons of value compatibilities informed a spatial GIS determination of conflict potential. The results were overlaid with the boundaries of nine marine protected areas in the region to illustrate the application of this method for marine spatial planning. The three near shore marine protected areas had at least one third of their area exhibiting conflict potential. Participatory mapping accompanied by conflict potential mapping provides important insights for spatial planning in these often-highly contested marine environments.

1. Introduction

Use of coastal and open sea areas has expanded rapidly in recent years contributing to conflict (Douvere, 2008; Douvere and Ehler, 2009; Weslawski et al., 2010; Yates et al., 2015). These can be user-user conflicts, for example between oil and gas development and fisheries, or between human use and the environment. Of particular concern are cumulative effects on the environment caused by the combined effects of over-fishing, pollution, and climate change (Douvere, 2008). Marine biodiversity continues to decline in the face of these cumulative impacts, with none of the planet's marine ecosystems unaffected by human influence (Halpern et al., 2008; Devillers et al., 2015). Marine spatial planning provides a means to identify potential conflicts based on use locations to develop management alternatives (Douvere, 2008; Douvere and Ehler, 2009).

Marine spatial planning (MSP) is increasingly seen as a way to achieve sustainable use of the seas by arbitrating between competing uses and long-term protection of the natural environment (Douvere, 2008; Yates et al., 2015). Spatial planning has a long history in land use planning, but is a relative newcomer to marine planning (Douvere, 2008; Douvere and Ehler, 2009; Kidd and Ellis, 2012). MSP is widely regarded as having conservation-based beginnings in the development of marine protected areas (Day, 2002; Douvere, 2008; Jay et al., 2012; Vince, 2014). Until recently, it was largely sectoral-based, limiting its capacity to identify and manage conflict between sectors (Douvere, 2008). In the last decade, MSP has increasingly been adopted in marine policy and management, with applications reported from Dutch, Belgium, German, Norwegian, U.K., Canadian, U.S., and Australian efforts (Douvere, 2008; Douvere and Ehler, 2009; Kenchington and Day, 2011; Jay et al.,

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2012; Jentoft and Knol, 2014; Vince, 2014).

Characteristics of MSP are its ecosystem-based approach, spatial focus, integration across sectors, and multi-level policy framework (Jentoft and Knol, 2014; Vince, 2014). Allocating use within three-dimensional space, and ecological, economic, and social objectives are other essential elements (Douvere and Ehler, 2009). MSP is explicitly recognized as a tool for managing conflicting uses, with Douvere and Ehler (2009) noting the leadership role taken by several European countries in using MSP to resolve marine conflicts and achieve conservation objectives. A spatial approach implies mapping which enables conflicts and compatibilities of human use to be made spatially explicit and therefore potentially manageable. Such mapping includes ecosystems and their features, and the human activities affecting these ecosystems (Douvere, 2008).

Marine protected areas are an ongoing focus of MSP (Day, 2002; Kenchington and Day, 2011) and the management tool of choice for conserving biodiversity for most jurisdictions (Agardy et al., 2003, 2011; Veitch et al., 2012; Pajaro et al., 2010). Such areas are a response to growing concerns regarding the impacts of anthropogenic activities including resource extraction (especially fishing), land-based pollution, invasive species, and climate change (Devillers et al., 2015; Halpern et al., 2008). Designation and management of marine protected areas, however, have been plagued by conflict. Marine protected areas are widely perceived as a conflict between conservation and fishing (Klein et al., 2008) where designation can increase conflict between fishers over a limited or declining resource (Agardy et al., 2003, 2011).

Understanding and managing possible conflicts associated with marine protected areas (MPAs) is essential for the future of the ocean's biodiversity. Although MPAs are a widely recognized conservation tool, they currently cover 8.4% of areas within coastal and marine national jurisdiction and only 0.25% of the seas beyond, in comparison to the 15.4% of the terrestrial world covered by protected areas (Juffe-Bignoli et al., 2014). The Aichi Biodiversity Targets, set as part of the Convention on Biological Diversity, prescribe formal protection of 10% of coastal and marine areas by 2020 (COB, 2016). More areas are needed, with conflict over current and intended uses being the largest obstacle (Devillers et al., 2015). Spatial approaches to their establishment are a widely touted solution (Yates et al., 2015).

Minimizing conflict can be achieved through an integrated approach to management underpinned by spatial planning (Douvere, 2008; Jentoft and Knol, 2014). MSP offers a potential solution and opportunity to identify priority MPAs across a region, and link MPA planning with other local, regional, and national planning efforts (Agardy et al., 2011). Ideally, MPA planning through the MSP rubric interprets conservation requirements within a broader framework of sustainable resource use (Kenchington and Day, 2011). MSP can also help move MPA planning beyond small, discrete sites to regions. Such a broadening is essential given that megafauna such as whales often traverse multiple national jurisdictions (Agardy et al., 2011).

A commitment to spatial planning, however, is not enough. Such efforts must include mapped information about people and their communities. Trouble in MPA establishment is likely when the presence of people in the systems is not recognized (Agardy et al., 2011). St Martin and Hall-Arber (2008) refer to a "cartographic silence" in current mapping of the human dimension of the marine environment. They note that current data collection efforts for MSP do not capture the complexity of human communities or their relationships to places and resources. This gap has persisted despite the awareness that marine ecosystems include human values, knowledge, needs, processes, and impacts. A comprehensive mapping of the social landscape, similar to that utilized for the biophysical landscape, is recommended (St Martin and Hall-Arber, 2008). Other MSP commentators have noted a lack of capacity to collect, analyze, and communicate data more generally (Vince, 2013) and difficulties in assessing compatibilities and tradeoffs because information on the spatial distribution of human impacts is missing (Halpern et al., 2008).

Mapping place-based values offers a way forward to address the social dimension of the marine environment and better understand conflict. Land suitability analyses using mapped values have been undertaken for over a decade (Reed and Brown, 2003) and have evolved into a decision support model called *values compatibility analysis* (Brown and Reed, 2012) where various land uses are examined for their compatibility (or not) with the values mapped in specific locations. Underpinning suitability and compatibility analysis is the idea that current and prospective land uses ought to be consistent with the types of values expressed in specific geographic locations. Brown and Weber (2012) note that mapped values identify *relationship* values that bridge fundamental *held* values and *assigned* values (i.e., values attached to things), and can help managers identify potential conflict areas, assess the compatibility of land uses (e.g., zoning in parks), and provide public input to manage public lands (and waters).

A common method for identifying place values has been Public Participation Geographic Information Systems (PPGIS) relying on participants, recruited in a variety of ways (Brown, 2016), to indicate places they value on maps. Brown and Raymond (2014) and Hausner et al. (2015) elaborate a number of methods for identifying and calculating conflict potential indices using PPGIS data, some based exclusively on mapped values, and others that include mapped land use preferences. Lowry et al. (2009) note the need for technical assistance on conflict resolution, with PPGIS mapping able to help by identifying the spatial location of potential conflict (see Brown and Donovan, 2013). The majority of PPGIS efforts to date, however, have been directed towards land use planning; coastal and marine mapping studies by Brown (2011), Klain and Chan (2012), Ruiz-Frau et al. (2011), and Brown et al. (2016) are notable exceptions.

As such, *the main aim of this paper is to develop and apply a spatial methodology for analyzing conflict potential in a large coastal area* while demonstrating that participatory mapping can provide much-needed social data for MSP. This study meets two outstanding research needs identified for effective MSP. The first is applying a participatory mapping methodology to assess the social dimension in MSP, described as the "missing layer" (St Martin and Hall-Arber, 2008). The second is providing a methodology for revealing and analyzing conflict, a central concern in planning for the future of the marine realm (e.g., Weslawski et al., 2010).

2. Methods

2.1. Study area and policy context

The Kimberley coastline, 13,296 km in length, bounds the remote northwestern corner of Australia. The Kimberley region, at 423,500 km^2, and three times the size of England, has a population of only 34,795 people, with 40% identifying as Indigenous (ABS, 2011). Economic activities associated with the coast include commercial fishing and aquaculture, oil and gas extraction and processing, iron ore mining, ports, tourism, and pastoralism. Broome, Derby, Wyndham and Kununurra are important service centres (Fig. 1).

The Kimberley region's rugged coastline encompasses sea cliffs, secluded beaches, coastal waterfalls and 1710 islands.[1] Wilson

[1] Obtained from intersecting our study area with 1:250,000 scale island layers.

(2013) describes the north-western margin of Australia as one of the biodiversity hotspots of our planet, a distinction acknowledged in WWF's inclusion of the Kimberley marine region in its *Global 200* inventory of priority places on the planet. It is one of the world's most ecologically diverse and intact tropical marine ecosystems (Mustoe and Edmunds, 2008).

The Western Australian Government has committed to designation of a suite of marine parks in State coastal waters in the Kimberley region based on these high biodiversity values and the potential for pressure to be placed on these values by extractive activities such as oil and gas production and tourism. In Australia, State governments are responsible for the designation and management of MPAs in State and Territory waters, which extend 3 NM seaward of the territorial sea baseline. At the time of writing (September 2016), three parks have been declared in these State waters (Roebuck Bay,[2] Eighty Mile Beach,[3] Camden Sound) and two are proposed with management plans underway (Horizontal Falls, North Kimberley).

The Commonwealth government is responsible for designation and management of areas in Commonwealth waters that extend from the seaward boundary of State and Territory coastal waters to the outer limit of the Exclusive Economic Zone, 200 NM from the territorial sea baseline; or outside Australia in an area that Australia has obligations to protect under an international agreement (AG, 2016). A number of marine reserves have been designated in these Commonwealth waters off the Kimberley coast, however, their future remains unclear as the Australian government finalises a review into their designation (http://www.environment.gov.au/marinereservesreview). Both State and Commonwealth MPAs are shown in Fig. 1, with the large offshore areas being Commonwealth reserves.

There is significant pressure in the region to further develop the economy through resource extraction and tourism. Recent controversy has affected the Broome community with a proposed gas processing hub north of town that was strongly supported by the WA Government. Differing opinions fractured the community and led to protests in Perth, the state's capital city, 3000 km to the south. The project has not gone ahead. A longer standing pressure has been efforts by more than 10 Indigenous Traditional Owner groups associated with the Kimberley coast to establish connection to land and sea through formalized land rights. This is a long running process in the Kimberley, with some groups having formal rights, while others are still in the early stages of such processes. Having such rights is vitally important for Indigenous people in Australia as it can enable Traditional Owners to accrue benefits from ‘consumptive’ uses such as oil/gas, mining, and tourism. Unregulated tourism leading to damage to cultural heritage is another point of potential conflict on the Kimberley coast.

2.2. Study design and execution

The sampling design focused on community of place – people living in the Kimberley or having a direct interest (i.e. tourists visiting the Kimberley, oil and gas industry, government organisations, environmental NGOs based in Perth). The goal was to obtain participation from as broad a range of stakeholders as possible. Investigating this broad range was important given the diversity of interests and conflict potential (as previously described) for this coastline. Previous research into the social values of marine and coastal environments has generally focused on only 1–2 groups, and most often fishers. Only a handful of studies (16% of all studies) have encompassed more than six different stakeholder groups (e.g., Jentoft et al., 2012).

A minimum of 25 participants is recommended when using polygons in participatory mapping (Brown and Pullar, 2012), however, this number was considered too low given the number of different stakeholder groups. A wide range of sample sizes characterize PPGIS, from 30 interviews in a recent interview-based study on Vancouver Island (Klain and Chan, 2012) to 3745 respondents in an online PPGIS survey for Helsinki, Finland (Kahila-Tani et al., 2015). Our rationale for seeking a sample size of 140–160 interviews was the time available for fieldwork traded-off against achieving the largest possible sample size. Significant time was also required to build relationships with Aboriginal Traditional Owners.

Several strategies were used to identify and recruit participants. For organizations (e.g., Nyamba Buru Yaruwu, Shire of Broome, Kimberley Coast Cruising Yacht Club), purposive sampling was used to interview members directly known to the researchers, or alternatively, the organization arranged interviews for the researchers. Convenience sampling was used with tourists and residents, particularly on the less remote Dampier Peninsula. With convenience sampling, the researchers sought to obtain a wide range of participants in age, gender, and life cycle stage (e.g., with young family, retired). Snowball sampling was the third strategy, with contacts in organizations or individuals asked to recommend others. Overarching these sampling strategies was a quota-based approach to obtain representation from the full range of interests in the Kimberley (Neuman, 2012).

Data collection relied on face-to-face, semi-structured interviews that were digitally recorded with the permission of participants. Questions addressed socio-demographic variables: age, gender, highest level of education, and normal place of residence. Respondents were allocated to an affiliation (e.g., resident, environmental NGO, tourist) based on their occupation and/or expressed interests at the time of interview. Most of the interview was allocated to questions eliciting place values from participants with questions such as ‘Where are important places to you along the Kimberley coast?’ and ‘Thinking about place [X], what do you value about it?’. Participants were asked to draw up to five polygons on maps of the Kimberley coastline (6 maps at 1: 1,000,000 scale) in response to these questions. A more detailed map (1:250,000) was provided for the Broome area. No restrictions were placed on participants regarding the shape or spatial extent of the polygons. A similarly ‘unconstrained’ approach was taken by Klain and Chan (2012) in mapping coastal values for Vancouver Island, by Ramirez-Gomez et al. (2013) in their research of five indigenous villages in South America, and by Black and Liljeblad (2006) in their mapping of place attachment in the Bitterroot National Forest in the U.S.

The mapped polygons were digitized to closely reflect the areas drawn by each participant. All interviews were transcribed and analyzed using grounded theory (Corbin and Strauss, 1990), an inductive technique used to generate themes. Our interpretist approach relied on the emergence of themes informed by knowledge of relevant literature (Corbin and Strauss, 1990). The themes of particular interest were place values with the goal of identifying mutually exclusive categories of values to code each polygon with one or more values. Analysis was facilitated by the qualitative software program NVIVO 10 (QSR International, 2013).

The emergent codes (values) were organized according to the Millennium Ecosystem Assessment (MEA , 2005) typology of: (1) direct use, consumptive values, (2) direct use, non-consumptive values, (3) indirect use values, and (4) non-use values. This

[2] Approximately 30% of the total area of this Marine Park is proposed (i.e. yet to be designated).

[3] Approximately 17% of the total area of this Marine Park is proposed (i.e. yet to be designated).

categorization provided the basis for developing conflict matrices where consumptive use values are assumed to have the potential to conflict with other uses given that consumption for one purpose (to realize one value) can lead to a reduction in another value. For example, commercial fishing may reduce recreational fishing opportunities (both are regarded in this study as consumptive values).

2.3. Spatial analysis

Five stages of spatial analysis were undertaken:

(1) Displaying valued areas as polygons on maps of the area.
(2) Linking the polygons with coded values from the interviews. Polygons were clipped to within 20 km of the landward extent of mean high water mark.
(3) Analyzing overlapping polygons to produce a hotspot map for each value.
(4) Generating conflict matrices and maps to show areas of conflict potential.
(5) Overlaying the results of (4) with MPA boundaries to illustrate the utility of mapping conflict potential in spaces of great public interest.

Stage (1) is self-explanatory. Stages (2) and (3) are described below under *2.3.1 Mapping and analyzing individual value hotspots*, Stage (4) in *2.3.2 Value compatibility as indicator of conflict potential*, and Stage (5) brings together the results from Stage 4 with MPA boundaries (*2.3.3. Relationship between conflict hotspots and MPAs*).

2.3.1. Mapping and analyzing individual value hotspots

Hotspot maps were generated for each value by calculating how frequently different participants selected the same places for the same value. A macro model was created in ArcGIS to split multi-part polygons (made 'multi-part' when they overlap with other polygons) into single polygon segments. This splitting allowed counts of spatial frequency based on the number of overlapping polygon (parts). A frequency table counting overlapping polygons allowed cartographic representation of 'individual hotspot maps' as outputs ranging from low to high.

The valued area in the study region was calculated as the geographic footprint of all combined value polygons. To identify the relative importance by sub-area, the percentage of the valued study area occupied by more than 10 polygons was computed for each value. Results provide the frequency of occurrence of each value and its relative importance by area. The hotspot maps were validated against existing tourism maps, high resolution topographic maps, and Google Earth to check for any obvious misalignment of values in geographic space, for example, camping value mapped in the ocean.

2.3.2. Value compatibility as indicator of conflict potential

An analysis of value compatibility underpinned examination of conflict potential for the Kimberley coastline and marine environment. A 2 km grid was placed across the valued area to allow standardization of geographic features of different size and shape. An analytical scale of 2 km was chosen to match the spatial scale of geographic features of interest such as river mouths and embayments. The complex coastline of the Kimberley requires this finer level of resolution to properly understand place-based values associated with geomorphic features such as beaches. Further, respondents were highly unlikely to map at resolutions below 2 km given that at a scale of 1: 1,000,000 for the maps provided, the width of a pencil line (i.e. about 1 mm) equals 1 km on the ground.

Conflict scores were calculated for each grid cell to produce two conflict potential maps, each underpinned by a conflict matrix. Several assumptions guided the scoring. First, values were allocated to one of the four Millennium Ecosystem Assessment categories (MEA , 2005). Second, values were hypothesized as being associated with the landscape as a common-pool resource (Healy, 1994) where use by one party detracts from use/enjoyment by another, and (generally) one party cannot exclude another. Thus, values are associated with resources that are non-exclusive and rival. Bringing these two characteristics together suggests that consumptive values could detract from other values, including other consumptive values. Third, conflict can be due to goal interference and/or social norm violation. For people in the Kimberley, an example of goal interference might be commercial fishing precluding a reasonable catch by recreational fishers. Social norms are how people determine what is acceptable or not in others' use of an area (Vaske and Donnelly, 2002). An example of social norm violation might be camping or recreating in an area of Aboriginal cultural significance that could be interpreted as disrespectful.

Two conflict matrices were generated. Table 1 provides scores for the pairwise comparison between direct use consumptive values (e.g., recreational fishing and commercial fishing). The assigned scores reflect the judgment of the research team regarding the compatibility of the values. Each pair of values was assigned a score of 1 (generally compatible), 2 (somewhat compatible) or 3 (largely incompatible). For example, tourism and Aboriginal culture is hypothesized to be largely incompatible (score = 3) due to potential goal interference (i.e. Aboriginal people may be thwarted in achieving desired cultural and environmental outcomes by the economic imperatives of tourism).[4] Table 2 provides pairwise comparisons for all other values with direct consumptive use values (e.g., biodiversity and recreation − fishing) using the same scoring system. The more intangible the value (e.g., bequest value), the more likely the consumptive use would violate social norms (refer to bottom right hand corner of Table 2). Note that many paired consumptive and non-consumptive values are generally compatible with a score of 1.

The conflict matrix scores were used to calculate an aggregate value compatibility score for all grid cells where more than one value occurred, i.e. there was potential for conflict.

The calculation of aggregate value compatibility scores is as follows:

$$\mathrm{VCS} = \sum_{i=0}^{n} r_i$$

where VCS is the aggregate value compatibility score per cell, n is the number of unique landscape values in the cell, and r_i is the compatibility rating for the ith value with a paired value that ranges from 1 to 3. The higher the VCS the higher the potential for conflict.

Approximately 10% of the 'valued' area had more than one value per cell and thus indicated potentially conflicted space. The aggregate value compatibility scores (VCS) were used to identify spatial areas with relatively low (yellow), medium (orange) and high (red) conflict potential on an ordinal scale. The breaks between these three categories were calculated using ± one standard deviation (SD) from the mean. Thus, the first interval ("low") was 0 to mean − 1SD, the second interval ("medium") was between the mean − 1SD and mean + 1SD, and the third interval ("high") was from the mean + 1SD to the maximum value.

[4] This is not a critique of tourism; rather a judgment that if poorly executed there is the potential for goal interference, i.e. interference with the aspirations of Aboriginal people.

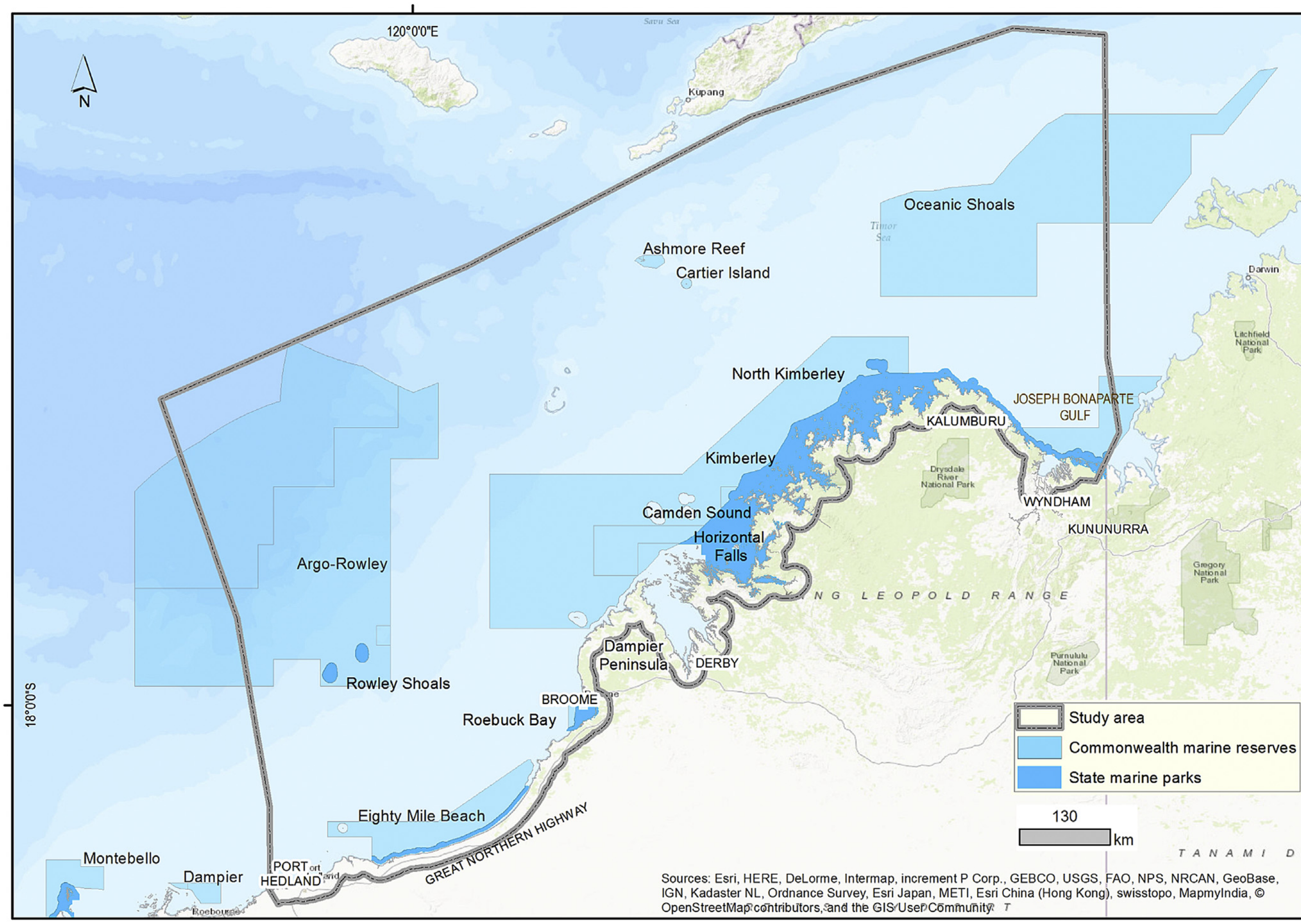

Fig. 1. Kimberley marine parks (current and proposed) (Source for marine park boundaries: Geoscience Australia 2014, Department of Parks and Wildlife Sept 2015).

2.3.3. Relationship between conflict hotspots and MPAs

To understand the potential implications of these conflict potential hotspots for marine and coastal planning, the hotspots were overlaid on a map of existing and proposed MPAs that included both Commonwealth and State reserves. The protected area boundary data from the two sources were merged to create a single protected areas spatial layer. In Australia, marine parks are multiple-use and equate most closely with IUCN category VI – *Protected area with sustainable use of natural resources* (IUCN, 2015). In these marine parks, commercial fishing is permitted in 'general use' zones with sanctuary (i.e. no-take) zones generally occupying 35% or less of the total area. We calculated the area and percentage of the hotspot components that were inside/outside of the protected areas or were within 50 km of a marine reserve boundary. For purposes of visualization, we generated maps showing the combined spatial overlay.

3. Results

3.1. Response and respondent characteristics

A total of 167 interviews were conducted with 232 individuals.

Table 1
Direct use consumptive values and direct use consumptive values hypothesized conflict potential matrix.

Direct use consumptive values x direct use consumptive values	Aboriginal culture	Recreation – camping	Recreation – fishing	Subsistence	Tourism	Commercial fishing & aquaculture
Aboriginal culture	–	2 GI	1	2 GI	3 GI	1
Recreation – camping		–	1	1	2 GI SNV	2 SNV
Recreation – fishing			–	1	1	2 GI SNV
Subsistence				–	1	2 GI SNV
Tourism					–	1
Commercial fishing & aquaculture						–

Scores: 3 – largely incompatible; 2 – somewhat compatible; 1 – generally compatible. GI – goal interference. SNV – social norm violation. Note. Aboriginal culture included as a direct use, consumptive value because of its potential to exclude other values/uses. Grey shading highlights scores of 2 and above.

Table 2
All other values and direct use consumptive values hypothesized conflict potential matrix.

All other values x direct use consumptive values	Aboriginal culture	Recreation – camping	Recreation – fishing	Subsistence	Tourism	Commercial fishing & aquaculture
Physical landscape	1	2 GI	1	1	2 GI	1
Therapeutic	1	1	1	1	1	1
Recreation – other (exploring, etc)	1	1	1	1	1	1
Social interactions & memory	1	1	1	1	1	1
Experiential	1	2 GI	1	1	2 GI SNV	2 GI SNV
Learning & research	1	1	1	1	1	1
Historical	1	1	1	1	1	1
Spiritual	1	1	1	1	1	1
Biodiversity	2 GI	2 GI	3 GI SNV	2 GI	3 GI	3 GI SNV
Bequest	1	2 SNV	2 SNV	2 SNV	2 SNV	2 SNV
Existence	1	1	1	1	2 SNV	2 SNV

Scores: 3 – largely incompatible; 2 – somewhat compatible; 1 – generally compatible. GI – goal interference. SNV – social norm violation. Note. Aboriginal culture included as a direct use, consumptive value because of its potential to exclude other values/uses. Grey shading highlights scores of 2 and above.

Table 3
Group affiliation of interviewees.

Group affiliation[a]	No. of respondents (%)	Group affiliation[a]	No. of respondents (%)
Tourist	66 (28.4%)	Environmental non-government organisation	7 (3.0%)
Aboriginal	50 (21.6%)	Ports & marine transport	5 (2.2%)
Resident	24 (10.3%)	Aquaculture	4 (1.7%)
Tourism industry	18 (7.8%)	Commercial fishing	4 (1.7%)
Yachties	18 (7.8%)	Mining, oil, gas & energy	4 (1.7%)
Government agencies	17 (7.3%)	Recreational fishing	4 (1.7%)
Aviation	7 (3.0%)	Other[b]	4 (1.7%)

[a] Details are for individuals rather than interviews as a number of interviews included two or more individuals.
[b] Individuals working with or who have worked with Aboriginal groups but are not Aboriginal.

Most interviews were completed with one person but some interviews had two or more people present. In these interviews, 986 polygons were drawn, with an average of 6 per interview (range of 1–30). Of the individuals interviewed, 61% were male, and 39% female, with about 73% of respondents completing either vocational or university education. The majority of respondents were from Western Australia (73.7%), with 23.3% from elsewhere in Australia, and 1.7% from overseas.

Allocation of respondents to an affiliation group was guided by 14 categories identified by the researchers (Table 3). Tourists (28.4%), Aboriginal people (21.6%) and Kimberley residents (not including Aboriginal people) (10.3%) were the stakeholder groups with the largest numbers of participants. Having respondents in 14 diverse categories, ranging from the aviation industry, to aquaculture to government agencies, reflects sampling efforts to include a broad a range of stakeholders. The interviews with Aboriginal people encompassed Traditional Owners and rangers from eight coastal groups: Mayala, Bardi, Baniol, Jabirr Jabirr, Nyul Nyul, Yaruwu, Karajarri, and Nyangamarta. Another four Traditional Owner groups were contacted, but they declined to be involved.

3.2. Value categories and values hotspot mapping

Analysis of the interview data produced 17 values categories grouped as (1) direct use, consumptive values, (2) direct use, non-consumptive values, (3) indirect use values, and (4) non-use values (MEA, 2005) (Table 4). None of these four groupings dominated the results (Table 4), although the non-use values of bequest and existence were least frequently identified (7% and 4% of interviews respectively). For the individual value categories, areas of biodiversity – the presence of flora and fauna of interest (especially marine fauna such as whales), reefs, and migratory shorebirds – were mapped in 80% of interviews followed by the physical landscape, mapped in 77% of interviews. The coastal zone with spectacular cliffs plunging into the sea, waterfalls and isolated sandy beaches, and an atmosphere of pristine remoteness, were quintessential elements of this mapped physical value.

Aboriginal culture (mapped in 63% of interviews, Table 4) encompassed both historic and cultural elements and included cultural sites, connection to country, evidence of historical use, and transmission of cultural knowledge. Other important value categories from the interviews included therapeutic values (62%), spiritual values held by non-Aboriginal people (11%), and subsistence value (44%) based on food collection and fresh water provisioning. This subsistence value also includes Aboriginal hunting and fishing.

The hotspot maps (frequencies of overlapping polygons in Fig. 2) reveal the entire coast is valued, but the intensity of value was spatially variable depending on the specific mapped value. Hotspots within MPAs include Montgomery Reef in Camden Sound Marine Park (physical landscape, Aboriginal culture, and biodiversity) and Horizontal Falls in Horizontal Falls Marine Park (experiential hotspot) (Figs. 1 and 2). Montgomery Reef has exceptional tidal ranges resulting in water marine animals such as turtles cascading off the Reef. At Horizontal Falls, this same extreme tidal range results in a spectacular ‘horizontal waterfall’ between two islands. Hotspots also occur outside the MPAs, especially the along the Dampier Peninsula for recreation, fishing, social interaction, and Aboriginal culture (Figs. 1 and 2). The Dampier Peninsula has a number of Aboriginal groups with Native Title claims either awarded or in progress. The Buccaneer Archipelago, to the southwest of Camden Sound, was the other obvious hotspot outside of MPAs, identified for a number of values (Figs. 1 and 2).

The physical landscape, biodiversity and Aboriginal culture occupied the greatest percentage of valued area (Table 5, column 2). Although the polygon counts were also high for these values (e.g., 261 polygons mapped for Aboriginal culture), there were also high counts for recreational fishing and other forms of recreation (348

Table 4
Value categories and their definitions.

Value category	Definition
Direct use, non-consumptive values	
Physical landscape (77%)	Values derived from physical landscape including aesthetics, tidal phenomenon, coastal geology, and 'wilderness'.
Therapeutic (62%)	Values derived from places making people feel mentally better, calm, or recharged.
Recreation – other (62%)	Values derived from places providing for outdoor recreation, based on exploration and unrelated to camping or fishing.
Social interaction & memories (56%)	Social values, including home and childhood memories, derived from a place.
Experiential (51%)	Values derived from places offering a unique personal experience including adventure and private experience.
Learning & research (34%)	Values derived from the ability to learn from a place. Often expressed in terms of scientific research.
Historical (19%)	Values derived from places of natural and human history with an emphasis on European and missionary history.
Spiritual (11%)	Values derived from places that are sacred, religious, or providing profound experiences of nature, as experienced by non-Aboriginal people.
Direct use, consumptive values	
Aboriginal culture (63%)	Values derived from the transmission of Aboriginal wisdom, knowledge, traditions, and way of life including cultural sites.
Recreation – camping (58%)	Values derived from places offering recreational activities centred on overnight or longer stays.
Recreation – fishing (54%)	Values derived from places offering recreational activities relating to catching fish and other marine life, e.g. mud crabs.
Subsistence (44%)	Values derived from places providing for subsistence food collection including Aboriginal hunting and fishing, fresh water provision.
Tourism (36%)	Eco or nature based tourism, Aboriginal cultural tourism.
Commercial fishing, pearling, aquaculture (24%)	Values derived from commercial fishing, aquaculture and pearling activities.
Indirect use values	
Biodiversity (80%)	Values derived from flora, fauna and/or other living organisms.
Non-use values	
Bequest (7%)	Values derived from places offering future generations the ability to experience places as they are now.
Existence (4%)	Values derived from knowing that a particular place or resource exists, regardless of having physically been to or used an area.

Table 5
Frequency statistics for mapped values.

Value	% of 'valued area'	Polygon count	Minimum area (km^2)	Maximum area (km^2)	Mean polygon area (km^2)	Mean number of overlapping polygons	Range in numbers of overlapping polygons
Physical landscape	15	407	1.0	59,603.2	1894.0	17	1–38
Biodiversity	9	321	1.0	52,033.2	1833.0	13	1–34
Aboriginal culture	8	261	1.0	59,603.2	1892.0	12	1–23
Experiential	3	114	1.0	59,603.2	2560.0	12	1–24
Recreation – fishing	2	348	1.0	52,033.2	929.0	10	1–20
Recreation – other	2	263	1.0	52,033.2	1164.6	13	1–24
Therapeutic	2	207	1.0	40,397.0	902.0	10	1–21
Social interaction & memories	1	187	1.0	40,397.0	795.0	10	1–19
Tourism	1	139	1.0	52,033.2	2010.0	8	1–17
Recreation – camping	<1	140	1.0	40,397.0	843.0	7	1–15
Subsistence	<1	113	1.0	40,397.0	1139.0	5	1–10
Learning & research	<1	94	1.0	40,397.0	1705.0	7	1–14
Historical	<1	78	1.0	39,742.0	1490.0	6	1–13
Commercial fishing & aquaculture	<1	48	1.0	59,603.2	3952.0	4	1–19
Spiritual	<1	41	1.0	42,854.0	1958.0	3	1–5
Bequest	<1	18	2.2	36,577.0	2677.0	2	1–4
Existence	<1	9	118.0	40,397.0	6886.0	2	1–4

and 263 respectively), although the percentage of the valued area occupied by each was relatively small. These results reflect the strong site-based nature of recreational use. There was even smaller mean polygon area for other site-specific values such as social interaction and memories, and recreation – camping (Table 5, 795 and 845 km^2 respectively) relative to the area for values that span large spaces such as commercial fishing (and aquaculture) (3952 km^2), and existence value with a mean polygon area of 6886 km^2.

3.3. Conflict potential mapping and relationship with marine protected areas

The conflict potential between direct use, consumptive values is given in Fig. 3 and Table 6 (refer to Table 4 for a list of these values). The areas of high conflict potential that span the Buccaneer Archipelago and the northern and western extent of the Dampier Peninsula are not within MPAs (Fig. 3). The high potential conflict area on the west coast of the Dampier Peninsula is the site of the proposed gas extraction facility. The offshore Commonwealth MPAs and the northern State-based MPAs have virtually no conflict potential.

The inset in Fig. 3 shows areas of conflict potential in two MPAs – Horizontal Falls and Camden Sound. For Horizontal Falls, almost three quarters of its area has conflict potential (Table 6, 71.4%) and for Camden Sound, one third of its area has conflict potential (37.6%). Roebuck Bay to the south (Fig. 1), a Ramsar listed wetland based on the number of migratory shorebirds that visit, also has a third of its area with conflict potential (33.8%). For all three MPAs, the level of conflict potential is medium to low with very little area scored as high. The mean conflict potential length per MPA is only 118.9 km/per MPA on the landward side of the MPAs (Table 6). This length is relatively small given the size of these marine parks (e.g., Camden Sound is 6785 km^2).

Conflict potential is also evident between 'all other values' and 'direct use consumptive values' (Fig. 4 and Table 7) in the MPAs, but with greater areal extent and intensity of conflict potential. Roebuck Bay had more than half (51.1%) of its area with conflict

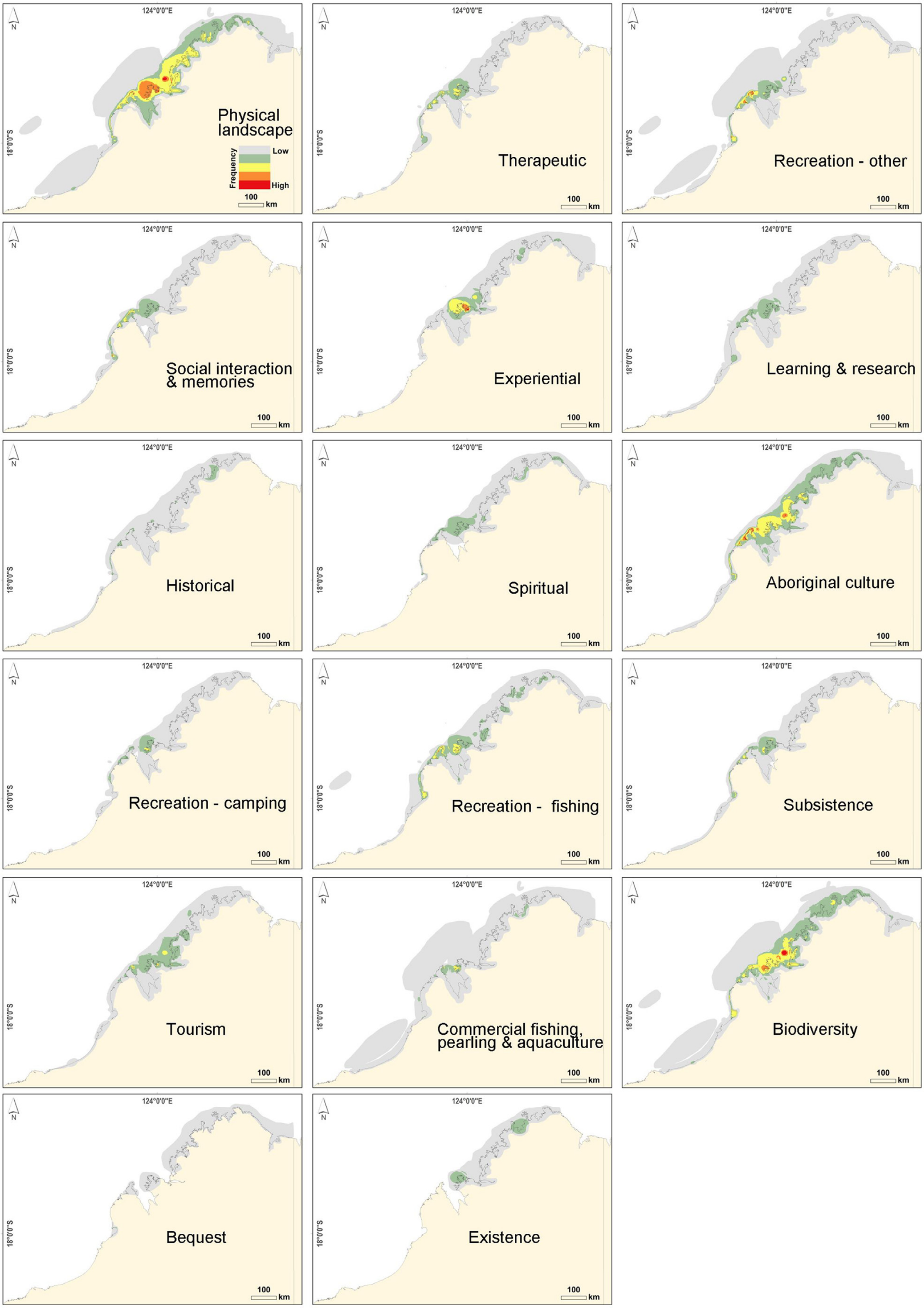

Fig. 2. Hotspot maps based on the frequencies of overlapping mapped polygons for 17 values, where red is high and grey is low. The range of frequencies (1–38) for each value is given in Table 5 (column 8). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

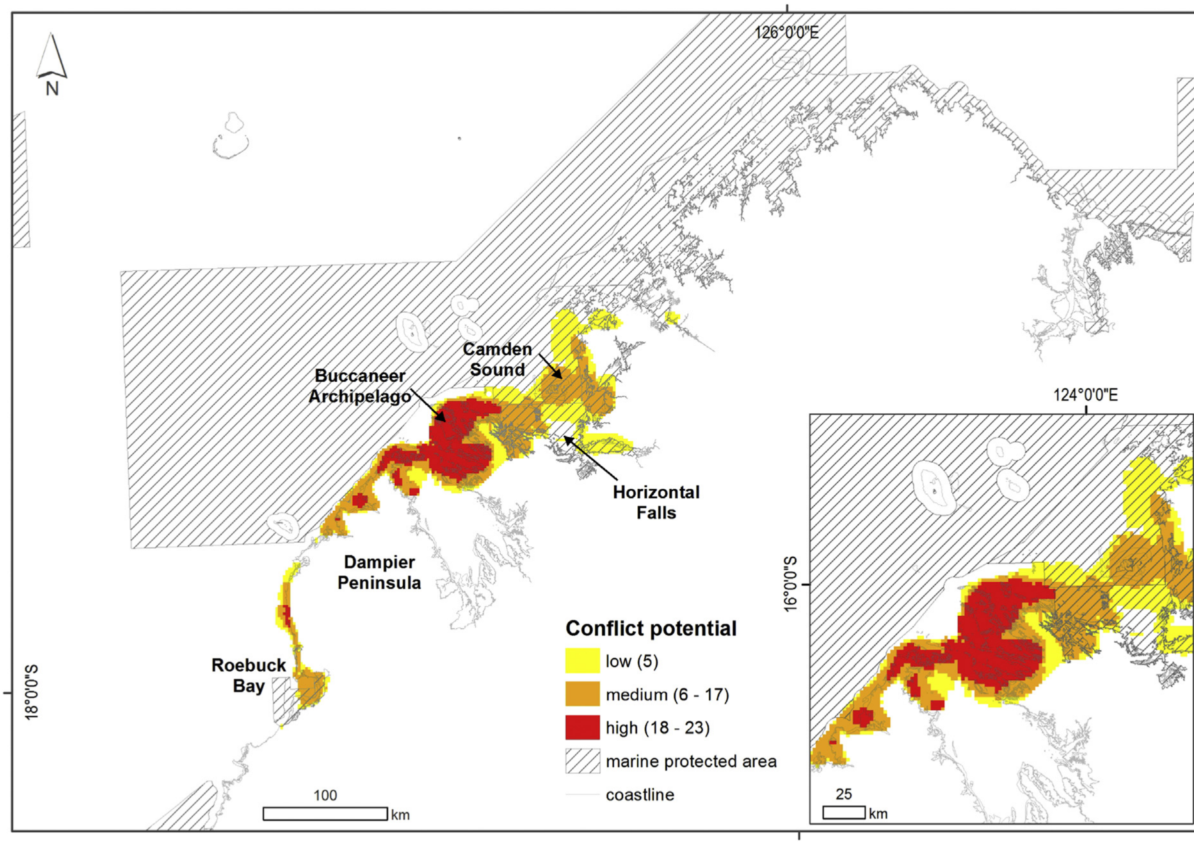

Fig. 3. Hypothesized conflict potential based on 'direct use consumptive values' and 'direct use consumptive values' with MPA boundaries added (see Table 4 for list of relevant values).

potential, compared with one third in the previous results (*cf.* Tables 7 and 6). Both Horizontal Falls and Camden Sound had more than three quarters of their area with conflict potential (82.3% and 84.2% respectively). As per the previous results for consumptive values only, the conflict potential in all three MPAs was largely medium to low. Of note, however, was 9.7% of Horizontal Falls being mapped as high conflict potential for 'all other values' and 'direct use consumptive values', compared to only 0.2% for 'direct use consumptive values' and 'direct use consumptive values' (*cf.* Tables 6 and 7). The areas of high conflict potential, largely outside MPAs, have expanded to cover more of the Buccaneer Archipelago and the northern and western extent of the Dampier Peninsula (Fig. 4). The offshore Commonwealth MPAs and the northern State-based MPAs again have virtually no conflict potential. The mean conflict potential length per MPA is only 256.7 km/MPA, on the landward side of the MPAs. This length is relatively small given the size of these MPAs.

4. Discussion

Place-based values are an essential social dimension for inclusion in MSP. Using interviews and participatory mapping, we found abundant and diverse place values along the remote Kimberley coastline of northwestern Australia, with physical, recreation, and biodiversity values expressed and mapped most frequently. The resultant hotspot maps clearly illustrate the place-based nature of values. To analyze and integrate the value distributions, we developed and applied a spatial methodology for analyzing conflict potential in the region. We found that two of the three smallest MPAs closest to the population centers of Broome and Derby had more than three quarters of their area with conflict potential when all values were considered. The percentage of area conflicted in these three marine parks was less when value compatibility analysis was restricted to consumptive values. Below we focus our discussion first on participatory mapping as a means of accessing social values for a wide range of stakeholders followed by conflict potential mapping. The contributions of these methodologies to MSP are highlighted as part of these discussions.

An important methodological contribution of this study was participatory mapping involving an extensive, diverse range of stakeholders. The entire coast was valued with biodiversity value mapped by 80% of participants. These biodiversity values appear well-known to study participants through their opposition to industrial development in the region, a visible multi-million dollar Kimberley Marine Research Program (http://www.wamsi.org.au/kimberley-marine-research-program-1), and a growing cruise ship tourism industry centered on the scenic, biological, and Aboriginal values of this coastline. For largely natural marine environments, biodiversity value emerges globally as a quintessential value that appears spatially bundled with aesthetic and recreation values. For example, Klain and Chan (2012) similarly identified biodiversity as the most mapped value in a participatory mapping study in the northern region of Vancouver Island, British Columbia, Van Riper and Kyle (2014) identified biodiversity value as the second most frequent value (aesthetics was first) in the Channel Islands National Park, U.S., and Brown (2011) found biodiversity value as the third most frequently mapped value behind aesthetic and recreation values in a participatory mapping study of Prince William Sound, Alaska.

The identification and mapping of value hotspots illustrate that

Table 6
'Direct use consumptive values' and 'direct use consumptive values' areas of conflict potential relative to MPAs of the Kimberley coast (see Table 4 for list of relevant values).

Marine protected area	High conflict potential km² (% of area)	Medium conflict potential km² (% of area)	Low conflict potential km² (% of area)	Total area of conflict potential km² (%)	MPA area within the study area km²	MPA boundary near conflict potential hotspots km⁺⁺
Eighty Mile Beach*⁺	0	0	0	0	14,546.29	0
Roebuck Bay*⁺	0	289.29 (28.11%)	58.75 (5.71%)	348.04 (33.81%)	1,029.31	150
Horizontal Falls*	5.28 (0.15%)	1,409.66 (39.74%)	1,117.00 (31.49%)	2,531.94 (71.38%)	3,546.94	220
Camden Sound*	2.64 (0.04%)	1,050.13 (15.48%)	1,496.11 (22.05%)	2,548.88 (37.57%)	6,784.99	400
North Kimberley*	0	0	0	0	19,576.03	0
Kimberley**	0	35.41 (0.05%)	12.17 (0.02%)	47.58 (0.06%)	75,146.53	300
Rowley Shoals*	0	0	0	0	899.82	0
Argo-Rowley Terrace**	0	0	0	0	3,024.71	0
Joseph Bonaparte Gulf**	0	0	0	0	3,775.98	0
TOTAL km² (& %) conflict potential *across this MPA system*	7.92 (0.01%)	2,784.49 (2.17%)	2,684.03 (2.09%)	5,476.44 (4.27%)	128,330.61 km² total area of MPAs	1,070 km of MPA system boundary near conflict potential hotspots
MEAN km² (& %) conflict potential *for an 'average' MPA in this system (9 in system)*	0.88 (0.02%)	309.39 (9.26%)	298.23 (6.59%)	608.49 (15.87%)	14,258.96 km² mean area for MPA within study area	118.89 km mean conflict length/MPA

* State waters. ** Commonwealth waters.
⁺ Includes proposed additions. ⁺⁺ Length of MPA boundary abutting or within 50 km of conflict potential hotspots (all 3 levels)
[light shading] $^1/_3$–$^2/_3$ of MPA potentially conflicted. [darker shading] >$^2/_3$ of MPA potentially conflicted.

different locations are important for different values and importantly, provides a method for inclusion and consideration of a relational understanding of space in MSP (Jay, 2012). Each value is related to a particular place based on participants' perceptions and experiences. Place-based mapping captures the relational nature of social-ecological systems (Karimi et al., 2015), particularly the complex and multi-faceted relationships of stakeholders with the natural environment. While descriptive hotspot maps of place-based values are an important starting point for understanding the complexity of space for MSP, it is the spatial relationships between values that add depth to understanding. Place-based ecosystem values occur in spatial "bundles" (Raudsepp-Hearne et al., 2010) that can represent "synergies" (De Vreese et al., 2016), or as framed in this study, the potential for conflict.

In this study, conflict potential was driven, in part, by the presence of biological values which were assumed to potentially goal interfere with other values, especially consumptive values. An ecological perspective for coastal areas can conflict with a perspective that views coasts as important for commodity or productivity values (Stocker and Kennedy, 2009). The other major driver of mapped conflict potential was consumptive uses such as tourism and commercial fishing, both with the potential to goal

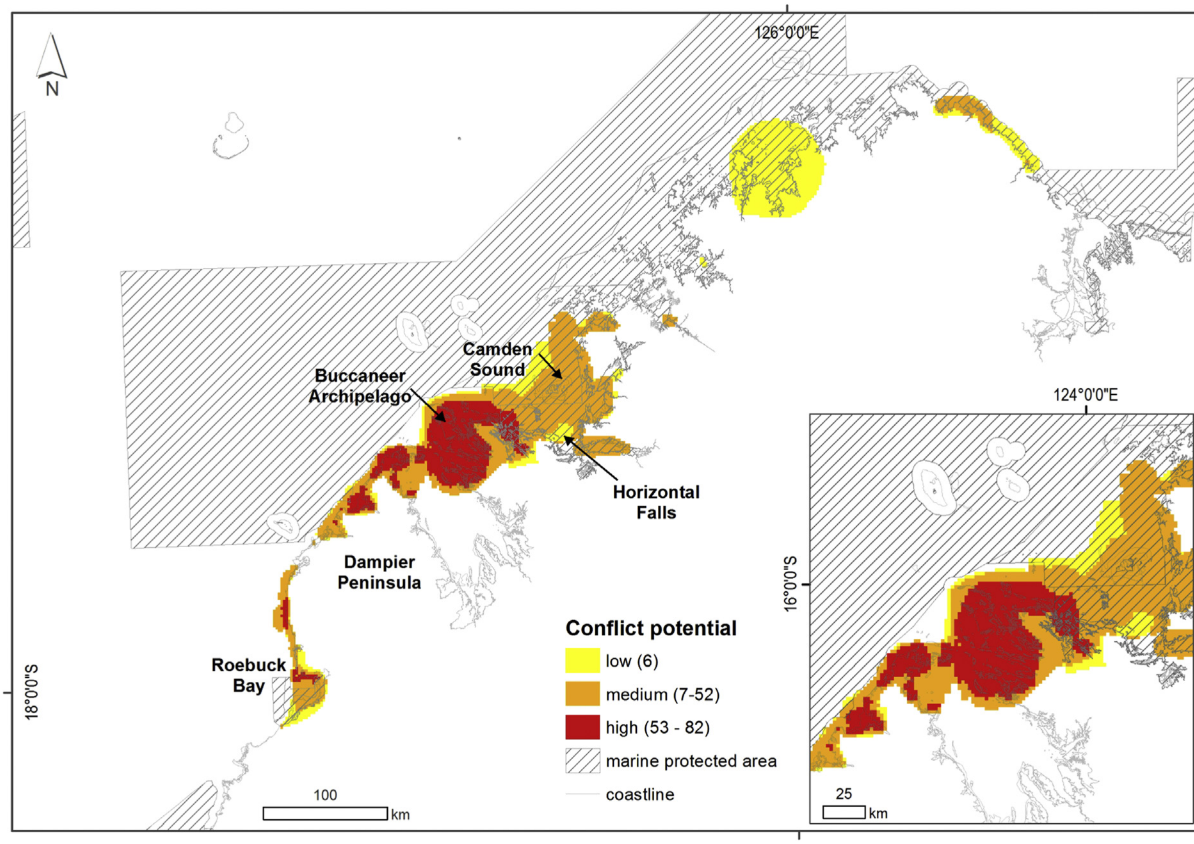

Fig. 4. Hypothesized conflict potential based 'all other values' and 'direct use consumptive values' with MPA boundaries added (see Table 4 for list of relevant values).

interfere and violate social norms. Weslawski et al. (2010), in a similarly conflict-centered approach to spatial analysis in Polish Marine Areas, assessed the potential for conflict through GIS mapping of multiple sectoral interests to determine the spatial extent and overlap. Their results mirror ours, with 62% of Polish Nature Protection Measures area identified as conflicted with commercial fishing interests. The extent of conflict potential in these Polish waters was driven by biodiversity and commercial fishing values, similar to the drivers of conflict potential in this study.

Potentially conflicted near shore space was not an unexpected result. The higher conflict potential of the "near shore" MPAs such as Roebuck Bay and Horizontal Falls, relative to the large offshore Commonwealth MPAs such as the Kimberley and Argo-Rowley MPAs, was most likely a product of their biodiversity values being better known (Wilson, 2014) and the widely held view that the biodiversity of coastal waters is in more immediate need of protection given their declining marine biodiversity (Devillers et al., 2015). The pattern of MPA reservation in the Kimberley seems to match the global process where larger, more remote reserves are the product of "residual reservation" (Devillers et al., 2015) with large MPAs located to minimize their impact on other uses such as fishing, extractive industries, and even tourism.

Identifying and analyzing conflict potential is integral to successful MSP given its identification as a tool for resolving conflict (Douvere and Ehler, 2009). The mapping process reported herein makes visually explicit the places where conflict is most likely. Jentoft and Knol (2014) note the importance of being able to provide good maps as part of conflict resolution and emphasize that MSP is more than a zoning activity, but also a process of negotiating interactions among users of marine environments comprising complex social-ecological systems, with multiple scales of ecological and governance systems that are ecologically and socially dynamic. Conflict potential maps, and the conflict matrices that support them, can provide a basis for such interactions as negotiations between those who value the marine spaces of interest. An interesting follow up study would be identifying how these values, conflicts and human impacts can be traded off in a systematic way to identify conservation priorities while minimizing human impacts and conflict.

A participatory mapping approach that provides hotspot maps contributes to the social dimension that has been identified as the "missing layer" in MSP (St Martin and Hall-Arber, 2008). Such an approach enables peoples' perceptions to be included in planning and decision making processes. MSP is an inherently political process, with social objectives achieved through the political process (Douvere and Ehler, 2009). Participatory mapping accompanied by conflict analysis can foster a proactive political process, informed by social data that offers a means for accessing place values underpinning conflict.

5. Conclusion

Given MSP is a wicked problem, there is never a 'final' solution to the problem, only its 'taming' (Jentoft and Knol, 2014). Solutions, by necessity, are negotiated and re-negotiated between stakeholders over time. Spatial planning is often a one-off project, but the wicked nature of marine issues requires recurrent negotiation and accompanying data collection. Additionally, spatial plans should be produced as a starting point for ongoing adaptation and refinement (Mills et al., 2015) rather than as a 'final' product. This requirement suggests the need for participatory mapping as a type

Table 7
'All other values' and 'direct use consumptive values' areas of conflict potential relative to MPAs of the Kimberley coast (see Table 4 for list of relevant values).

Marine protected area	High conflict potential km^2 (% of area)	Medium conflict potential km^2 (% of area)	Low conflict potential km^2 (% of area)	Total area of conflict potential km^2 (%)	MPA area km^2	MPA boundary near conflict potential hotspots km[++]
Eighty Mile Beach*[+]	0	0	0	0	14,546.29	0
Roebuck Bay*[+]	15.47 (1.50%)	400.84 (38.94%)	110.11 (10.70%)	526.42 (51.14%)	1,029.31	350
Horizontal Falls*	342.73 (9.66%)	2,334.57 (65.82%)	241.06 (6.80%)	2,918.36 (82.28%)	3,546.94	350
Camden Sound*	0.69 (0.01%)	5,018.72 (73.97%)	692.83 (10.21%)	5,712.24 (84.19%)	6,784.99	350
North Kimberley*	0	0	0	0	19,576.03	350
Kimberley**	7.01 (0.01%)	47.11 (0.06%)	25.78 (0.03%)	79.90 (0.11%)	75,146.53	910
Rowley Shoals*	0	0	0	0	899.82	0
Argo-Rowley Terrace**	0	0	0	0	3,024.71	0
Joseph Bonaparte Gulf**	0	0	0	0	3,775.98	0
TOTAL km^2 (& %) conflict potential *across this MPA system*	365.90 (0.29%)	7,801.24 (6.08%)	1,069.78 (0.83%)	9,236.92 (7.20%)	128,330.61 km^2 total area of MPAs	2,310 km of MPA system boundary near conflict potential hotspots
MEAN km^2 (& %) conflict potential *for an 'average' MPA in this system*	40.66 (1.24%)	866.80 (19.87%)	118.86 (3.08%)	1,026.32 (24.19%)	14,258.96 km^2 mean area for an MPA	256.67 km mean conflict length/MPA

* State waters. ** Commonwealth waters.
[+] Includes proposed additions. [++] Length of MPA boundary abutting or within 50 km of conflict potential hotspots (all 3 levels).
[light shading] $^1/_3$–$^2/_3$rds of MPA potentially conflicted. [darker shading] >$^2/_3$rds of MPA potentially conflicted.

of social monitoring to refine current plans and adapt to changing future conditions. Mapped values in terrestrial landscapes appear relatively stable over time such that a five-year monitoring cycle would appear sufficient in the absence of major changes to the systems.

Use conflicts seem more and more likely to increase as more MPAs are created, emphasizing the importance of MSP as a conflict resolution tool. This paper provided a methodology to contribute the "missing layer" of social data and a means for identifying potentially conflicted space. The challenge now is to further explore the utility of these methodologies for other MPA systems and large marine spaces more generally. We must remember, however, that participatory mapping on its own is not a solution to conflict. MSP is an inherently political process (Douvere and Ehler, 2009) and as such, stakeholder participation in the process, in addition to having social layers available to MSP, is the only sensible way forward.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jenvman.2016.12.026.

References

ABS (Australian Bureau of Statistics), 2011. 2011 Census Data (accessed 27 August 2015). http://www.censusdata.abs.gov.au.

AG (Australian Government Department of the Environment), 2016. Commonwealth Marine Reserves – Legal Framework (accessed 4 March 2016). http://www.environment.gov.au/topics/marine/marine-reserves/overview/legal-framework.

Agardy, T., Bridgewater, P., Crosby, M.P., Day, D., Dayton, P.K., Kenchington, R., Laffoley, D., McConney, P., Murray, P.A., Parks, J.E., Peau, L., 2003. Dangerous targets? Unresolved issues and ideological clashes around marine protected areas. Aquatic Conservation Mar. Freshw. Ecosyst. 13, 353–367.

Agardy, T., di Sciara, G.N., Christie, P., 2011. Mind the gap: addressing the shortcomings of marine protected areas through large scale marine spatial planning. Mar. Policy 35, 226–232.

Black, A.E., Liljeblad, A., 2006. Integrating Social Values in Vegetation Models via GIS: the Missing Link for the Bitterroot National Forest, JFSP Project No. 04-2-1-114 Final Report. Aldo Leopold Wilderness Research Institute, Montana.

Brown, G., 2016. A Review of Sampling Effects and Response Bias in Internet Participatory Mapping (PPGIS/PGIS/VGI). Transactions in GIS.

Brown, G., 2011. Identifying landscape values in Prince William Sound with public participation geographic information systems (PPGIS). In: Poe, A., Gimblett, R. (Eds.), Sustainable Wildlands: a Prince William Sound Case Study of Science and Community-based Strategies for Managing Human Use (accessed April 17, 2016). http://www.landscapemap2.org/publications/chapterv22.pdf.

Brown, G., Pullar, 2012. An evaluation of the use of points versus polygons in Public Participation Geographic Information Systems (PPGIS) using quasi-experimental design and Monte Carlo simulation. Int. J. Geogr. Inf. Sci. 26 (2), 231–246.

Brown, G., Reed, P., 2012. Values compatibility analysis: integrating public values in a forest planning decision support system. Appl. Spatial Analysis Policy 5 (4), 31.

Brown, G., Weber, D., 2012. Measuring change in place values using public participation GIS (PPGIS). Appl. Geogr. 34, 316–324.

Brown, G., Donovan, S., 2013. Escaping the national forest planning quagmire: using public participation GIS (PPGIS) to assess acceptable national forest use. J. For. 111 (2), 115–125.

Brown, G., Raymond, C.M., 2014. Methods for identifying land use conflict potential using participatory mapping. Landsc. Urban Plan. 122, 196–208.

Brown, G., Strickland-Munro, J., Kobryn, H., Moore, S.A., 2016. Stakeholder analysis for marine conservation planning using public participation GIS. Appl. Geogr. 67, 77–93. http://dx.doi.org/10.1016/j.apgeog.2015.12.004.

COB (Convention on Biological Diversity), 2016. Aichi Biodiversity Targets (Accessed 5 April 2017) https://www.cbd.int/sp/targets/.

Corbin, J., Strauss, A., 1990. Basics of Qualitative Research: Grounded Theory Procedures and Techniques. Sage, Newbury Park.

Day, J., 2002. Zoning: lessons from the great barrier reef marine park. Ocean Coast. Manag. 45, 139–156.

Devillers, R., Pressey, R.L., Grech, A., Kittinger, J.N., Edgar, G.J., Ward, T., Watson, R., 2015. Reinventing residual reserves in the sea: are we favouring ease of establishment over need for protection? Aquatic Conservation Mar. Freshw. Ecosyst. 25, 480–504.

De Vreese, R., Leys, M., Fontaine, C.M., Dendoncker, N., 2016. Social mapping of perceived ecosystem services supply – the role of social landscape metrics and social hotspots for integrated ecosystem services assessment, landscape planning and management. Ecol. Indic. 66, 517–533.

Douvere, F., 2008. The importance of marine spatial planning in advancing ecosystem-based sea use management. Mar. Policy 32, 762–771.

Douvere, F., Ehler, C.N., 2009. New perspectives on sea use management: initial findings from European experience with marine spatial planning. J. Environ. Manag. 90, 77–88.

Halpern, B.S., Walbridge, S., Selkoe, K.A., Kappel, C.V., Micheli, F., D'Agrosa, C., Bruno, J.F., Casey, K.S., Ebert, C., Fox, H.E., et al., 2008. A global map of human impact on marine ecosystems. Science 319, 948–952.

Hausner, V.H., Brown, G., Lægreid, E., 2015. Effects of land tenure and protected areas on ecosystem services and land use preferences in Norway. Land Use Policy 49, 446–461.

Healy, R.G., 1994. The "common pool" problem in tourism landscapes. Ann. Tour. Res. 21 (3), 596–611.

IUCN (International Union for Conservation of Nature), 2015. IUCN Protected Areas Categories System (accessed 17 December 2015). http://www.iucn.org/about/work/programmes/gpap_home/gpap_quality/gpap_pacategories/.

Jay, S., 2012. Marine space: manoeuvring towards a relational understanding. J. Environ. Policy Plan. 14 (1), 81–96.

Jay, S., Ellis, G., Kidd, S., 2012. Marine spatial planning: a new frontier? J. Environ. Policy Plan. 14 (1), 1–5.

Jentoft, S., Knol, M., 2014. Marine spatial planning: risk or opportunity for fisheries in the North Sea? Marit. Stud. 12, 13 (16 pp).

Jentoft, S., Pascual-Fernardez, J.J., De la Cruz Modino, R., Gonzalez-Ramallal, M., Chuenpagdee, R., 2012. What stakeholders think about marine protected areas: case studies from Spain. Hum. Ecol. 40, 185–197. http://dx.doi.org/10.1007/s10745-012-9459-6.

Juffe-Bignoli, D., Burgess, N.D., Bingham, H., Belle, E.M.S., de Lima, M.G., Deguignet, M., et al., 2014. Protected Planet Report 2014. UNEP-WCMC, Cambridge, UK.

Kahila-Tani, M., Broberg, A., Kyttä, M., Tyger, T., 2015. Let the citizens map—public participation GIS as a planning support system in the Helsinki Master Plan Process. Plan. Pract. Res. http://dx.doi.org/10.1080/02697459.2015.1104203.

Karimi, A., Brown, G., Hockings, M., 2015. Methods and participatory approaches for identifying socialecological hotspots. Appl. Geogr. 63, 9–20.

Kenchington, R.A., Day, J.C., 2011. Zoning, a fundamental cornerstone of effective marine spatial planning: lessons learnt from the Great Barrier Reef, Australia. J. Coast. Conservation 15, 271–278.

Kidd, S., Ellis, G., 2012. From the land to sea and back again? Using terrestrial planning to understand the process of marine spatial planning. J. Environ. Policy Plan. 14, 49–66.

Klain, S.C., Chan, K.M.A., 2012. Navigating coastal values: participatory mapping of ecosystem services for spatial planning. Ecol. Econ. 82, 104–113. http://dx.doi.org/10.1016/j.ecolecon.2012.07.008.

Klein, C.J., Chan, A., Kircher, L., Cundiff, A.J., Gardner, N., Hrovat, Y., Scholz, A., Kendall, B.E., Airame, S., 2008. Striking a balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas. Conserv. Biol. 22 (3), 691–700.

Lowry, G.K., White, A.T., Christie, P., 2009. Scaling up to networks of marine protected areas in the Philippines: biophysical, legal, institutional, and social considerations. Coast. Manag. 37, 274–290.

MEA (Millennium Ecosystem Assessment), 2005. Ecosystems and Human Well-being. A Framework for Assessment, Chapter 6. Concepts of Ecosystem Value and Valuating Approaches. Island Press, Washington DC, pp. 127–147.

Mills, M., Weeks, R., Pressey, R.L., Gleason, M.G., Eisma-Osario, R.-L., Lombard, A.T., Harris, J.M., Killmer, A.B., White, A., Morrison, T.H., 2015. Real-world progress in overcoming the challenges of adaptive spatial planning in marine protected areas. Biol. Conserv. 181, 54–63.

Mustoe, S., Edmunds, M., 2008. Coastal and Marine Natural Values of the Kimberley. WWF-Australia, Sydney, NSW.

Neuman, W.L., 2012. Social Research Methods: Qualitative and Quantitative Approaches. Pearson, Boston.

Pajaro, M.G., Mulrennan, M.E., Vincent, A.C.J., 2010. Toward an integrated marine protected areas policy: connecting the global to the local. Environment. Dev. Sustain. 12, 945–965.

QSR International, 2013. NVIVO 10. Computer Software. QSR International, Victoria, Australia.

Ramirez-Gomez, S.O.I., Brown, G., Tjon Sie Fat, A., 2013. Participatory mapping with indigenous communities for conservation: challenges and lessons from Suriname. Electron. J. Inf. Syst. Dev. Ctries. 58 (2), 1–22.

Raudsepp-Hearne, C., Peterson, G.D., Bennett, E.M., 2010. Ecosystem service bundles for analyzing tradeoffs in diverse landscapes. Proc. Natl. Acad. Sci. 107 (11), 5242–5247.

Reed, P., Brown, G., 2003. Values suitability analysis: a methodology for identifying and integrating public perceptions of ecosystem values in forest planning. J. Environ. Plan. Manag. 46 (5), 643–658.

Ruiz-Frau, A., Edwards-Jones, G., Kaiser, M.J., 2011. Mapping stakeholder values for coastal zone management. Mar. Ecol. Prog. Ser. 434, 239–249.

St Martin, K., Hall-Arber, M., 2008. The missing layer: geo-technologies, communities, and implications for marine spatial planning. Mar. Policy 32, 779–786.

Stocker, L., Kennedy, D., 2009. Cultural models of the coast in Australia: towards sustainability. Coast. Manag. 37, 387–404.

Van Riper, C.J., Kyle, G.T., 2014. Capturing multiple values of ecosystem services shaped by environmental worldviews: a spatial analysis. J. Environ. Manag. 145, 374–384. http://dx.doi.org/10.1016/j.jenvman.2014.06.014.

Vaske, J., Donnelly, M., 2002. Generalizing the encounter-norm crowding relationship. Leis. Sci. 24, 255–269.

Veitch, L., Dulvy, N.K., Koldewey, H., Lieberman, S., Pauly, D., Roberts, C.M., Rogers, A.D., Baillie, J.E.M., 2012. Avoiding empty ocean commitments at Rio+20. Science 336, 1383–1385.

Vince, J., 2013. Marine bioregional plans and implementation issues: Australia's oceans policy process. Mar. Policy 38, 325–329.

Vince, J., 2014. Oceans governance and marine spatial planning in Australia. Aust. J. Marit. Ocean Aff. 6, 5–17.

Węsławski, J.M., Urbański, J., Kryla-Staszewska, L., Andrulewicz, E., Linkowski, T., Kuzebski, E., Meissner, W., Otremba, Z., Piwowarczyk, J., 2010. The different uses of sea space in Polish Marine Areas: is conflict inevitable? Oceanologia 52, 513–530.

Wilson, B., 2013. The Biogeography of the Australian North West Shelf: Environmental Change and Life's Response. Elsevier, Burlington, MA.

Wilson, B., 2014. Kimberley marine biota. History and environment. Rec. West. Aust. Mus. Suppl. 84, 1–18. http://dx.doi.org/10.18195/issn.0313-122x.84.2014.001-018.

Yates, K., Schoeman, D.S., Klein, C.J., 2015. Ocean zoning for conservation, fisheries and marine renewable energy: assessing trade-offs and co-location opportunities. J. Environ. Manag. 152, 201–209.