Applied Geography 67 (2016) 77–93

Contents lists available at ScienceDirect

Applied Geography

journal homepage: www.elsevier.com/locate/apgeog

Stakeholder analysis for marine conservation planning using public participation GIS

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ARTICLE INFO

Article history:
Received 30 October 2015
Received in revised form
7 December 2015
Accepted 14 December 2015
Available online 23 December 2015

Keywords:
Stakeholder analysis
Conservation
PPGIS
Marine protected areas

ABSTRACT

Stakeholders are presumed to represent different interests for marine and coastal areas with the potential to influence marine protected area planning and management. We implemented a public participation GIS (PPGIS) system in the remote Kimberley region of Australia to identify the spatial values and preferences for marine and coastal areas. We assessed similarities and differences in PPGIS participants (N = 578) using three operational definitions for "stakeholder" based on: (1) self-identified group, (2) self-identified future interests in the region, and (3) participant value orientation that reflects a preferred trade-off between environmental and economic outcomes. We found moderate levels of association between alternative stakeholder classifications that were logically related to general and place-specific participatory mapping behavior in the study region. We then analyzed how stakeholder classifications influence specific management preferences for proposed marine protected areas (MPAs) in the study region. Conservation-related values and preferences dominated the mapped results in all proposed marine reserves, the likely result of volunteer sampling bias by conservation stakeholder interests participating in the study. However, we suggest these results may also reflect the highly politicized process of marine conservation planning in the Kimberley where conservation efforts have recently emerged and galvanized to oppose a major offshore gas development and associated land-based infrastructure. Consistent with other participatory mapping studies, our results indicate that the chosen operational definition for stakeholder group such as group *identity* versus *interests* can influence participatory mapping outcomes, with implications for MPA designation and management. Future research is needed to better understand the strengths and limitations of participatory mapping that is framed in stakeholder perspectives, especially when sampling relies heavily on volunteer recruitment and participation methods that appear predisposed to participatory bias. In parallel, practical efforts to ensure that social research efforts such as this are included in MPA planning must remain of the highest priority for scientists and managers alike.

1. Introduction

Marine protected areas (MPAs) are designated to enhance conservation of marine resources and provide an important tool to counter the rapid degradation of the world's oceans (Lubchenco, Palumbi, Gaines, & Andelman, 2003). Despite significant growth in recent years, the establishment of MPAs, as a percent of total marine area, lags terrestrial protected areas. In 2014, MPAs covered 3.4% of the global ocean area, 8.4% of the area under national jurisdiction (0–200 nautical miles), and 10.9% of all coastal waters, but only 0.25% of marine areas beyond national jurisdiction (Juffe-Bignoli et al., 2014). In contrast, 15.4% of the world's terrestrial areas, including inland waters, have protected area status (Juffe-Bignoli et al., 2014).

Stakeholders play a critical role in the establishment and management of MPAs which are often political and contentious as illustrated by events in Australia. In 2012, a Labor government announced an additional 2.3 million square kilometers would be added to the current Commonwealth marine reserve system, bringing the system total to over 3.1 million square kilometers. Marine reserve plans were approved for implementation in 2014,

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http://dx.doi.org/10.1016/j.apgeog.2015.12.004
0143-6228/

but with an electoral change to a Liberal government, the plans were suspended and the government commissioned a review of the system. The government stated the review fulfilled an election commitment to ensure that "management arrangements for the reserves reflect genuine and thorough consultation with stakeholders and are informed by the best available science" (Department of Environment, 2015).[1] Commercial fishing stakeholders were presumed to have played an important role in the government decision to suspend the reserve plans pending review.

There are multiple definitions for stakeholders, but one that fits the purpose of this study defines stakeholders as "any group of people, organized or unorganized, who share a common interest or stake in a particular issue or system … who can be at any level or position in society, from global, national and regional concerns down to the level of household or intra-household, and be groups of any size or aggregation" (Grimble & Wellard, 1997, p. 176). Stakeholders can also include the nebulous categories of 'future generations', the 'national interest' and 'wider society' (Grimble & Wellard, 1997), with these categories often evoked as justification for the establishment of MPAs. A key distinction between stakeholders is those who affect decisions and those who are affected by decisions. This distinction has significant implications for stakeholder analysis methods that can identify stakeholder groups prior to the initiation of a planning process, or alternatively provide for the emergence of stakeholder groups through an inductive analysis of expressed preferences (Brown, de Bie, & Weber, 2015).

There is widespread agreement on the importance of incorporating stakeholders in meaningful participation for effective marine conservation planning and management (Charles & Wilson, 2009; Lundquist & Granek, 2005; Pomeroy & Douvere, 2008; Pollnac, Crawford, & Gorospe, 2001, 2010; Voyer, Gladstone, & Goodall, 2012), in all phases of marine conservation ranging from marine protected area design to implementation and management. Stakeholders can assist in the identification of marine spatial plan priorities and objectives, the selection of options, plan implementation and enforcement, and evaluation of outcomes (Pomeroy & Douvere, 2008). MPAs are unlikely to meet their biological or social goals unless the human dimensions or people-oriented factors are integrated into the MPA design and evaluation process (Charles & Wilson, 2009; Christie et al., 2003; Gruby, Gray, Campbell, & Acton, 2015; Pollnac et al., 2010). Indeed, some argue that MPA failure may be attributable to consultative failures in the early stages when an MPA is conceived, communicated, and discussed among stakeholders (Chuenpagdee et al., 2013). MPA designs that include both biodiversity conservation goals and multiple socioeconomic stakeholder interests are more likely to protect marine ecosystems (Christie, 2004; Klein et al., 2008), while MPA management strategies that find the "middle-ground" between government-led and community-based approaches may be most effective (Jones, 2002).

The purpose of stakeholder analysis is to inform the development and consideration of alternatives in the early stages of a project or proposal, or if a project or plan has been implemented, to effectively manage stakeholders and conflicts over the duration of the plan. Stakeholder analysis is particularly relevant for environmental issues such as marine conservation because potential impacts tend to cross-cut biophysical and social systems, involve multiple uses and user groups, contain externalities and trade-offs, and affect future availability or productivity of resources (Grimble & Chan, 1995; Grimble & Wellard, 1997). In the application of stakeholder analysis to marine conservation, stakeholder analysis appears especially important in the early stages of design and zoning of MPAs, but stakeholders can also be used to verify evidence collected in support of a marine spatial planning process (Shucksmith, Gray, Kelly, & Tweddle, 2014).

The need to identify and understand stakeholders is part of broader and increasing urgent calls to include social science in MPA planning and management. Gruby et al. (2015) advocate for research scoping the diverse values of MPAs, while Voyer et al. (2012) focus on social assessment, encouraging researchers to move beyond public participation. This paper makes an important contribution in progressing social research, with a strong spatial focus, while also extending our understanding of social assessments. This contribution involves understanding stakeholders and how their operational identity affects analysis of planning and management alternatives. Voyer et al. (2012) note the need to move beyond a generic perspective on public participation; this paper progresses our understanding by interrogating who is the "public" and provides methods for doing so.

1.1. Stakeholder analysis methods and participatory mapping

There are a range of methods for identifying and analyzing stakeholder perspectives for environmental planning and management, including marine conservation. For example, Reed et al. (2009) describe three steps in stakeholder analysis: identifying stakeholders, differentiating between and categorizing stakeholders, and investigating relationships between stakeholders. Grimble and Chan (1995) describe the following steps: identify the purpose of analysis (goals); develop an understanding of the system, decision makers, and drivers of decisions; identify principal stakeholders; investigate stakeholder interests, characteristics and circumstances; and identify patterns and contexts of interaction between stakeholders. Stakeholder analysis, as traditionally practiced, identifies key individuals and groups through expert-driven processes that do not usually include broad-based social surveys. For example, the Marine Life Protection Act initiative in California that established a system of marine reserves used a regional stakeholder group process where stakeholders were identified, appointed, and worked in small, staff-supported groups to develop multiple MPA proposals over the course of about one year (Fox et al., 2013).

The emergence of participatory mapping methods using geographic information is a relatively recent addition to the stakeholder analysis toolbox. Public participation geographic information systems (PPGIS), participatory GIS (PGIS), and volunteered geographic information (VGI) describe methods that commonly engage lay people (non-experts) to generate spatial information for a wide range of urban, regional, and environmental planning applications (see Brown & Kyttä, 2014; Brown, 2012, 2005). Participatory mapping for environmental applications often identifies place-based values (Brown & Reed, 2000) and place-based preferences (Brown, 2006). Mapped place-based values and preferences, when combined with participant characteristics, provide an alternative approach to common stakeholder identification methods. Most PPGIS/PGIS/VGI processes that inform environmental planning involve stakeholders given the broad definition of stakeholder that includes those affected by planning decisions. Schlossberg and Shuford (2005) describe how the term "public" in PPGIS can refer to decision makers, implementers, affected individuals, interested observers, or the general public—in other words, stakeholders.

With participatory mapping, the focus of stakeholder analysis expands from individuals and groups perceived to have more direct influence/power over marine planning decisions to those that are potentially affected by decisions. These individuals can be termed "latent" stakeholders (Mitchell, Agle, & Wood, 1997) that possess

[1] https://www.environment.gov.au/marinereservesreview/about.

legitimacy for involvement, but not necessarily the power or urgency to engage with the process. Participatory mapping can also explicitly sample for "definitive" stakeholders (Mitchell et al., 1997), that is, those possessing power, legitimacy, and urgency for involvement. In one of the few examples of participatory mapping for marine spatial planning, Ruiz-Frau, Edwards-Jones, and Kaiser (2011) mapped stakeholders' values for marine ecosystems and assessed their preferences for the location and type of marine protected areas (MPAs) around the coast of Wales (UK). Individuals belonging to member organizations of the Wales Maritime and Coastal Partnership were interviewed and requested to participate. The researchers concluded that mapping stakeholders' values in the marine environment was useful for identifying areas better suited for specific management regulations and for the development of comprehensive marine spatial plans.

There have been several non-marine participatory mapping studies that have targeted stakeholders to assess protected area management preferences. Eadens et al. (2009) conducted participatory mapping workshops with 35 individuals representing six stakeholder groups for recreation planning in a Bahamian National Park. They modeled spatial agreement by examining the spatial overlap in future activity zones mapped by the six groups. "Strong" agreement was defined as areas mapped by five to six groups and "some" agreement was defined as areas mapped by three to four groups. This method resulted in a park map showing areas of spatial agreement for protection, ecotourism, and hunting activities. In another example, Brown et al. (2015) used participatory mapping and non-spatial survey questions to identify public land values and preferences in the state of Victoria, Australia. Different stakeholder groups were identified based on responses to survey questions asking about general preferences for public lands. These stakeholder groups were shown to have different place-specific preferences depending on the public land type and location.

1.2. Stakeholder analysis for marine spatial planning

Spatial data collected using PPGIS/PGIS/VGI methods can be used in the early stages of planning to identify concentrations of place-specific marine values (both use and non-use values) that when combined with ecological data, can identify preliminary marine protected areas and/or management zones. Assessing the human dimensions of the marine environment through this inductive, "bottom-up" approach presumes that high concentrations or "hotspots" of values will emerge from the participatory mapping activity. If the study area contains both existing and prospective MPAs, values mapped within existing MPAs can be used as an empirical basis for identifying similar areas for inclusion in the reserve system. The method was demonstrated by Raymond and Brown (2006) to identify the suitable areas for national park expansion in Victoria, Australia, based on the distribution of values located in existing, proximate national parks. The supporting logic is that existing MPAs have place-specific values that differ from surrounding marine areas such that the type and relative abundance of these mapped values can be used to identify similarly important areas.

As demonstrated in this paper, participatory mapping can also be used in the intermediate stages of a marine planning process to evaluate whether mapped values and preferences are consistent with agency-proposed MPAs. A terrestrial analogue for this approach was a study by Brown (2006) on Kangaroo Island (KI), Australia that examined whether the type and distribution of mapped values and preferences by KI residents were logically consistent with development plan zones. This evaluative approach can provide evidence in support of proposed MPAs or identify the need for modification to MPA spatial design. When analyzing mapped data within proposed MPAs, the potential for conflict between specific stakeholder groups may become evident in the spatial distribution of mapped values and preferences. Examining the spatial distribution of mapped preferences appears more important than values because preferences have a closer nexus to the proposed purpose(s) for establishing an MPA.

The method for identifying stakeholder groups in participatory mapping is critically important because it determines how the spatial data are segmented and analyzed. Stakeholders can be pre-identified and recruited to engage in the participatory mapping activity or non-spatial participant variables collected as part of the mapping process can be used to identify stakeholder groups in post-mapping analysis. Even if stakeholders are pre-identified, it would appear prudent to also compare mapped values and preferences against presumed stakeholder roles.

The question of what constitutes a stakeholder for the purpose of marine spatial planning is non-trivial. The first complexity is jurisdiction. In the case of Australia, marine reserves can be created in Commonwealth waters that extend from three nautical miles off the coast to the outer limit of the exclusive economic zone (200 nautical miles). Marine reserves established in coastal waters are the responsibility of State governments. A second complexity is that marine reserves for conservation function as quasi-public goods. A national or state government that designates a marine reserve for conservation may not be able to exclude others from benefit, especially for pelagic species. Other nations, organizations, and individuals become stakeholders in the establishment and management of MPAs. A third complexity influencing the delineation of stakeholders is the actual level of protection within MPAs which can vary considerably from strict "no-take" zones to the allowance of extractive activities such as commercial fishing.

1.3. Stakeholder analysis of proposed MPAs in the Kimberley region, Australia

The aims of this study are to describe stakeholder analysis methods and to report findings from a participatory GIS process to assess coastal and marine values in the Kimberley region of Australia (Strickland-Munro, Kobryn, Moore, & Brown, 2015a). With limited research on stakeholder analysis methods using participatory mapping, the methods assume equal importance with the actual results for marine planning in the study region. The steps in stakeholder analysis and how each step was operationalized appear in Fig. 1. We implemented the first three steps in this paper to inform a discussion about the fourth step, how and whether to integrate stakeholder analysis into MPA decision support. The output of the first step, stakeholder identification, influences subsequent steps in the process, emphasizing the importance of getting this step right. In this study, we used three operational methods for identifying stakeholder groups: participant self-identification with a group (*identity*), participant expression of interests in the study region (*interests*), and participant responses to a trade-off question that asked participants to express a preference for environmental or economic outcomes (*value orientation*). These stakeholder classifications formed the basis for the following research questions:

(1) How should stakeholder groups be identified for purposes of participatory mapping? We operationalize and evaluate three methods for classifying participants into stakeholder groups based on *identity*, *interests*, and general *value orientation*.
(2) Are stakeholder groupings logically related to the type of values and preferences mapped in participatory GIS? We evaluate the propensity for different stakeholder groups to

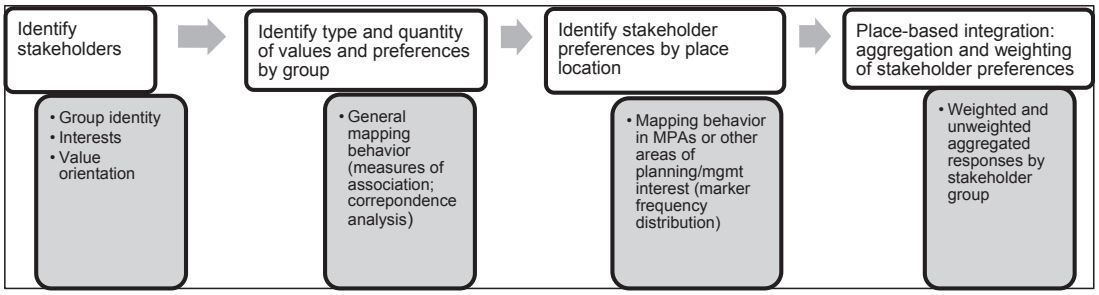

Fig. 1. Sequence of steps in stakeholder analysis using participatory GIS for evaluating proposed MPAs.

map certain types of marine and coastal values and preferences.

(3) Is stakeholder identity related to *place-specific* mapping behavior? We evaluate the distribution of mapped preferences by stakeholder groups in two of five proposed MPAs in the study region using stakeholder definitions based on *identity* and *interests*.

Following analyses and results, we reflect on the findings which have strong implications for the use of participatory mapping methods for marine spatial planning. We provide some guidance for participatory mapping processes that seek to integrate multiple stakeholder groups for decision support.

2. Methods

2.1. Study location and context

The Kimberley region is located in northwest Australia in the state of Western Australia (see Fig. 2). The research study area extends from the southwestern end of Eighty Mile Beach to the Northern Territory border, a coastline 13,296 km in length at low water mark including islands. The marine environment of the Kimberley is noted for its 'very good' ecological condition and is included in the 3.7% of global oceans considered to have experienced very low human impact (Halpern et al., 2008). In 2011, the Western Australian Government introduced the Kimberley Science and Conservation Strategy (GoWA, 2011) with a commitment to introduce a system of marine reserves through the establishment of four new, multiple-use marine parks located at Eighty Mile Beach, Roebuck Bay, Lalang-garram/Camden Sound and North Kimberley (see Fig. 2). The marine parks were to cover 48% of the Kimberley's coastal waters and increase the area of State marine parks and reserves from approximately 1.5 million hectares to 4.1 million hectares (Thomson-Dans, Overman, & Moncrieff, 2011). A fifth marine park for the iconic Horizontal Falls area was announced in 2013 as well as plans to extend the North Kimberley Marine Park eastwards to the Northern Territory border. To date, three parks have been established, at Eighty Mile Beach, Horizontal Falls and Lalang-garram/Camden Sound, with the remaining parks yet to be formalized. In Western Australia, marine parks include "no take" zones as well as "general use" zones where extractive activities are allowed. These existing and proposed State marine parks complement four Commonwealth marine reserves located at Eighty Mile Beach, Roebuck Bay, Argo-Rowley Terrace and 'Kimberley' (Fig. 2). Commonwealth marine reserves are managed primarily for biodiversity conservation but also allow for a range of activities including commercial and recreational fishing, tourism, mining operations, and pearling and aquaculture (CoA, 2014). All existing and proposed State marine parks are to be managed with Aboriginal Traditional Owners under formal joint management agreements.

The principle economic activities associated with the Kimberley coast include commercial fishing, pearling and other aquaculture (e.g., barramundi farming), oil and gas extraction, iron ore mining, and tourism. The Kimberley towns of Broome, Derby, Wyndham and Kununurra are important service centers. The region's population is about 35,000 with 43.5% being of Aboriginal heritage (ABS, 2011).

2.2. Data collection process

The research team designed, pre-tested and implemented an internet-based PPGIS application for data collection. The application used a Google® maps interface where study participants could drag and drop digital markers onto a map of the Kimberley region (see Strickland-Munro et al., 2015a for a detailed description of the PPGIS web interface). The process consisted of participants entering the PPGIS website, providing informed consent, completing non-spatial survey questions (pre- and post-mapping), and engaging in the mapping activity. Pre-mapping questions included socio-demographic information, how respondents learned of the study, and their self-identified knowledge of the Kimberley region.

The post-mapping survey contained three questions designed to classify participants into stakeholder categories based on group *identity*, *interests*, and *value orientation*. The first question asked participants to self-identify with a group based on the following choices: Kimberley resident; visitor; Aboriginal; commercial fishing, pearling or aquaculture; Commonwealth, state or local government; NGO; tourism industry; oil/gas industry; and researcher. A second question asked participants regarding their dominant *interest* in the Kimberley region. This question was framed by asking participants to indicate their greatest concern for the region with the following choices available: making sure there are recreational opportunities for local people; ensuring rights of Traditional Owners/Aboriginal people in the region are respected; protecting biological and ecological features found in the region; maintaining and developing tourism opportunities; ensuring the region provides natural resources; and ensuring marine/coastal plans are developed/implemented. A third question asked participants to think about their own personal values and to position themselves on the 7-point Environmental-Economics Priority (EEP) scale, which contrasts environmental and economic priorities in coastal and marine management. Variants of the EEP scale have been used in 19 studies indicating its reliability as a survey instrument (Abrams, Kelly, Shindler, and Wilton, 2005). In this study, the EEP was used to classify participants into the categories of "environmental", "balanced", and "economic". The scale was anchored at opposite ends with contrasting statements: "Highest priority should be given to maintaining natural environmental conditions even if there are negative economic consequences" versus "Highest priority should be given to economic considerations even if there

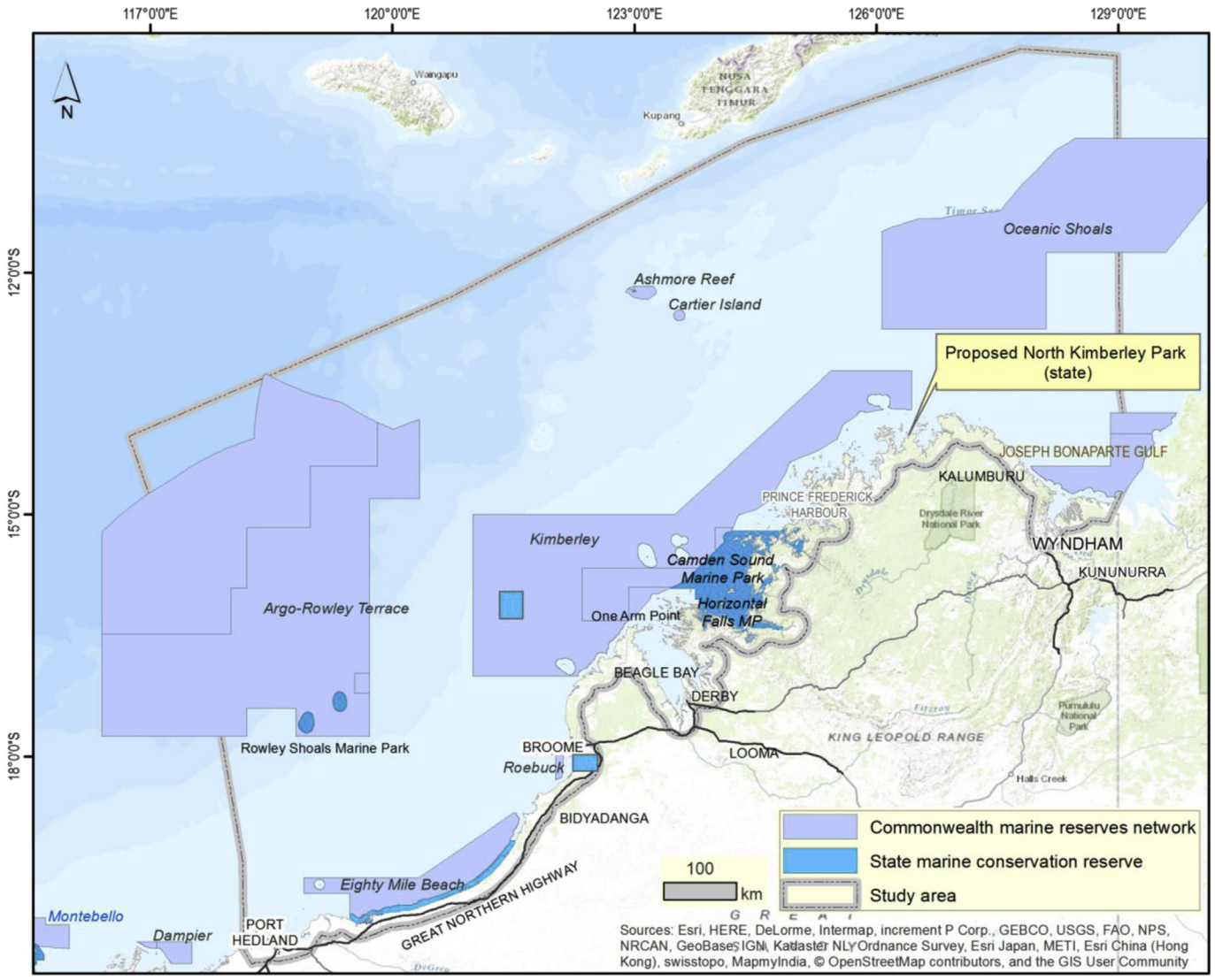

Fig. 2. Kimberley marine parks (current and proposed) (Source: Geoscience Australia 2014, Department of Parks and Wildlife).

are negative environmental consequences." The scale midpoint was anchored with the statement, "Environmental and economic factors should be given equal priority."

For the mapping activity, two different panels contained markers representing 14 values and 13 management preferences (see definitions in Table 1). The value markers were selected based on inductive, emergent categories obtained from interview data collected in an earlier phase of this research (see Strickland-Munro, Moore, Kobryn, & Palmer, 2015b), consideration of values unique to the Kimberley region detailed in planning documents, and similar values found in a typology developed by Brown and Reed (2000) and used in multiple PPGIS studies (see Brown & Kyttä, 2014). The selection of management preference markers was also informed by these same interviews (e.g., key management issues for the region, see Strickland-Munro et al., 2015b), relevant policy documents (e.g., Draft Kimberley Regional Planning and Infrastructure Framework, Government of Western Australia, 2014), and consultation with key research partners including the Western Australia Marine Science Institute (WAMSI) and the Western Australia Department of Parks and Wildlife.

Sampling design and recruitment efforts were guided by the desire to engage the greatest possible number of participants, a formidable challenge given the Kimberley's vastness, small, dispersed population, and the region's limited accessibility. The population of interest included people living in or visiting the Kimberley, as well as geographically-remote individuals with an ongoing interest in the region. Stakeholder groups involved in a prior research phase were targeted for participation and included Aboriginal Traditional Owners; non-Aboriginal residents; tourists and the tourism industry; commercial and recreational fishing, and aquaculture; federal, state and local government; industry (mining, oil, gas and tidal energy interests); marine transport and aviation; and environmental non-government organizations. Sampling also included scientific researchers, particularly those involved in other WAMSI research projects, and individuals from a commercial, online internet panel. A minimum target of 350 participants was set across all stakeholder groups. In total, 120 official and informal representative bodies were approached to participate in, and assist with further recruitment for, the PPGIS survey over the months of April–July 2015.

Eight methods of recruitment were used to obtain PPGIS participation: (1) direct personal contact by members of the research team, (2) postal invitation, (3) email initiated by stakeholder organizations that provided a link to the PPGIS website, (4)

Table 1
Values and management preference markers with operational definitions.

Values	Operational definition
Scenic/aesthetic	These areas are valuable to me because they contain attractive scenery including sights, smells, and sounds.
Recreation	These areas are valuable because they are where I enjoy spending my leisure time with family, friends or by myself, participating in outdoor recreation activities (e.g., camping, walking, exploring).
Fishing (recreational)	These areas are valuable because they are where I can go fishing for fish and other marine life like crabs, cockles, and oysters.
Economic (non-tourism)	These areas are valuable because they provide natural resources that can be used by people (e.g., minerals, oil, gas, fish, pearls, pastoralism).
Nature-based tourism	These areas are valuable because they provide tourism opportunities, including Aboriginal cultural tourism, in a generally undisturbed environment.
Learning/education/ research	These areas are valuable because they enable us to learn about the environment through observation or study.
Biological/conservation	These areas are valuable due to the presence of plants, wildlife & habitat including marine wildlife, reefs, migratory shorebirds & mangroves.
Aboriginal culture/heritage	These areas are valuable because they allow Traditional Owners to maintain connection to their coastal & sea country through identity and place, family networks, spiritual practice and resource gathering.
European heritage	These areas are valuable because they reflect European history associated with exploration, pastoralism, missions, commercial fishing & the Second World War.
Therapeutic/health	These areas are valuable because they make me feel better mentally and/or physically.
Spiritual	These areas are valuable because they are sacred, religious, or spiritually special places or because I feel reverence and respect for nature here.
Intrinsic/existence	These areas are valuable in their own right, no matter what I or others think about them.
Wilderness/pristine	These areas are valuable because they are wild, uninhabited, or relatively untouched by European activity.
Special places	These places are special. Please indicate why the place is special to you.

Preferences	Operational definition
Increase conservation/ protection	Increase conservation and protection here (e.g. from fishing pressure, encroaching development).
Increase aboriginal management	Increase Aboriginal control and management of lands and waters, including ongoing resourcing for Ranger groups.
Add recreation facilities	Add new recreation facilities (e.g. boat launching ramp, picnic area, campsite, toilet block).
Add tourism services/ development	Add new nature-based tourism facilities (e.g., visitor center, eco-resort, pontoon).
Improve/increase access	Improve or increase vehicular access (i.e., from no access to 4WD access or from 4WD track to 2WD road).
Restrict/limit access	Restrict or limit access to protect environmental or culturally sensitive places, or to ensure the quality of visitor experiences.
Commercial fishing/ aquaculture	Allow commercial fishing/aquaculture/pearling in this area.
No commercial fishing/ aquaculture	Do not allow commercial fishing/aquaculture/pearling in this area.
Oil/gas development	Allow oil/gas extraction and/or processing here.
No oil/gas development	Do not allow oil/gas extraction and/or processing here.
New port development	New port development here.
No new port development	No new port development here.
Other preference	Describe the land or sea use you would prefer (or not prefer) to see in this location.

social media, (5) local news media, (6) printed survey invitation cards, (7) announcement written in organization newsletters, and (8) informal referrals to friends, family, or professional contacts from any of the other methods.

A prototype of the PPGIS survey was pilot tested in March 2015 using three approaches. The first approach requested different groups complete the survey, consisting of middle to senior level managers in the WA Department of Parks and Wildlife, social science researchers at Murdoch University, and recreational users of the Kimberley coast. In the second approach, a member of the research team demonstrated the PPGIS survey in meetings with Broome-based participant groups. A third approach consisted of a focus group with individuals from the University of Western Australia. Feedback from these sources was used to adjust the mapping scale, increase the clarity of mapping instructions, and add extra place names and reference locations. The final version of the PPGIS survey was launched in April, 2015. Data were collected for four months and the PPGIS survey was closed on July 31, 2015.

2.3. Analyses

2.3.1. Associations between stakeholder operational definitions

Stakeholder groups were operationalized based on responses to survey questions that asked participants about their *identity*, *interests*, and *value orientation*. There were nine stakeholder *identity* categories, six *interest* categories, and three *value orientation* categories. We examined the distribution of participants across the three operational definitions using the chi-square test for independence to determine whether the alternative stakeholder classifications were associated. Following a significant finding of association, standardized residuals were calculated to assess which pair-wise categorical variables most contribute to the overall association. The standardized residual was calculated by dividing the residual value by the standard error of the residual. Standardized

residuals greater than +1.96 (rounded to +2.0) indicated significantly greater observed frequencies than expected, while standardized residuals less than −1.96 (rounded to −2.0) indicated significantly fewer observed counts than expected. Larger absolute values of standardized residuals indicated greater deviation from expected counts, thus contributing more to the overall measure of association.

2.3.2. Relationship between stakeholder group and mapped values and preferences (non-place specific)

To determine whether stakeholder groups were logically related to the type of values and preferences mapped in the Kimberley region, we used chi-square analysis to determine if there was a greater propensity for different stakeholder groups to map certain types of values and preferences. If a participant mapped one or more of a given value or preference marker category, that individual was classified as "YES" for the category, otherwise "NO". This categorical treatment of mapped markers (presence/absence) was preferred over analyzing mean differences by stakeholder group which can be influenced by a few individuals placing a large number of markers within a marker category.

We calculated chi-squared statistics and standardized residuals to determine whether the number of individuals within a stakeholder group mapping a given value or preference differed significantly from the number of individuals that would be expected to map the category. The chi-square analysis was supplemented with correspondence analysis to visualize the relationship between stakeholder groups and the types of values and preferences mapped by the groups. Correspondence analysis describes the relationship between two nominal variables in a contingency table while simultaneously describing the relationships between the categories of each variable. Mathematically, correspondence analysis decomposes the chi-square measure of association of the two nominal variables into components, much like principal components analysis of continuous data. It computes row and column scores and produces normalized plots based on the scores. In the normalized plot, the distances between category points reflect the relationships between the nominal categories, with similar categories plotted close to each other. Interpretation of the plot is by rows (i.e., stakeholder group) and columns (categories of values or preferences).

2.3.3. Relationship between stakeholder group and place-specific preferences for MPAs

To determine if stakeholder classification is related to place-specific mapping behavior, we examined the spatial distribution of mapped preferences by stakeholder group in two of the five proposed MPAs in the study region—North Kimberley and Roebuck Bay. These two areas were selected because i) the North Kimberley proposed MPA had the greatest quantity of spatial data for analysis and is the most remote from human settlement, and ii) the Roebuck Bay proposed MPA is the least remote with proximate human settlement (Broome). We examined the spatial distributions in the two MPAs using the two operational definitions for stakeholder group, *identity* and *interest*. We generated radar (a.k.a., spider) charts of these preference frequency distributions for each stakeholder group to visually identify patterns of similarity and difference for each MPA.

3. Results

3.1. Participation rates and response profile

A total of 763 individuals fully or partially participated in the PPGIS survey. A partial completion was an individual that accessed the website and mapped one or more markers, but did not complete the post-mapping survey questions. Our analysis was limited to full completions (n = 578) because the stakeholder identity questions were contained in the post-mapping survey questions. Of these participants, n = 206 individuals originated from the online internet panel while the remainder (n = 372) came from other recruitment methods. Of all the recruitment methods, direct email was the most effective method, accounting for about 64% of participants. Social media and personal referral accounted for about 13% and 8% of participants respectively. A postal mailing to Kimberley residential households in the main population centers of Broome, Derby, Wyndham and Kununurra (n = 2915) was not an effective recruitment strategy due, in part, to inaccurate postal addresses, with about half of the letter invitations returned as undeliverable. Postal recruitment accounted for about 4% of participants with Kimberley residents accounting for approximately a third of study participants.

The sociodemographic profile of participants was examined and compared to Kimberley and Western Australia census data (ABS, 2011). Participants were 52% female compared to census data of 50% for WA and 47% for the Kimberley region. The largest groups of participants were aged 55–64 (21%), 35–44 (21%), and 45–54 (20%) respectively, with this age profile being somewhat younger than comparable census data. Aboriginal participants were significantly underrepresented in the response with only about 2% of participants identifying themselves as Aboriginal compared to 43.5% of the Kimberley population and the statewide proportion in Western Australia of 3.4%. Participants were strongly biased toward higher levels of formal education (bachelor or postgraduate degrees), a finding consistent with previously reported PPGIS studies (Brown & Kyttä, 2014).

3.2. Associations between stakeholder classifications

We generated chi-square contingency tables with standardized residuals to examine the distribution of participants across stakeholder classifications (*identity*, *interests*, and *value orientation*). The largest number of participants self-identified as *visitors* (n = 271, 51%) followed by *government* (n = 68, 13%) and *residents* (n = 61, 11%). The smallest *identity* classification was *commercial fishing* (n = 5, 1%). The largest stakeholder *interest* category was *ecology* (n = 343, 60%) followed by Aboriginal (n = 67, 12%), an interesting result given that only 12 participants self-identified as Aboriginal. Stakeholder *identity* was significantly associated with stakeholder *interests* ($\chi^2 = 113.7$, $df = 40$, $p < 0.001$) with moderate strength of association (Cramer's V = 0.21, $p < 0.001$). There were multiple, significant pairwise associations (residuals > +2.0) between *oil/gas* identity and *resource* interests (+3.8), *Aboriginal* identity and *Aboriginal* interests (+2.2), and *resident* identity with *recreational* interests (+6.4) (see Table 2).

The largest number of participants selected an *environmental* value orientation on the EEP scale (n = 406, 71%), followed by a *balanced* orientation (n = 116, 20%), and *economic* orientation (n = 51, 9%). Stakeholder *interest* was significantly associated with *value orientation* ($\chi^2 = 98.1$, $df = 10$, $p < 0.001$) with moderate strength of association (Cramer's V = 0.30, $p < 0.001$). The standardized residuals indicate that participants with ecological interests were significantly over-represented in the *environmental* value group (+2.8), while recreation (−2.4), tourism (−2.0), and resource (−2.0) interests were under-represented (see Table 3). The opposite relationships were found in the *balanced* group with recreation (+4.3), tourism (+2.7), and resource (+3.8) interests over-represented, and ecology (−3.9) interests under-represented. In the *economic* group, ecology interests were also under-represented (−2.3).

Table 2
Association of stakeholder ***identity*** with stakeholder ***interest***. The overall association is significant ($\chi^2 = 113.720$, $df = 40$, $p < 0.001$) with standardized residuals less than −2.0 (pink) or greater than 2.0 (green) highlighted. Note: caution is warranted in interpreting results as 67% of cells have expected counts less than 5.

Identity		Interest						Total
		Recreation	Aboriginal	Ecology	Tourism	Resources	Planning	
Oil/gas	Count	1	0	8	2	4	2	17
	%	5.9%	0.0%	47.1%	11.8%	23.5%	11.8%	100.0%
	Residual	-.1	-1.4	-.8	.8	3.8	.4	
Tourism	Count	1	1	16	4	0	3	25
	%	4.0%	4.0%	64.0%	16.0%	0.0%	12.0%	100.0%
	Residual	-.5	-1.1	.2	1.8	-1.0	.5	
Government	Count	4	7	46	2	1	4	64
	%	6.3%	10.9%	71.9%	3.1%	1.6%	6.3%	100.0%
	Residual	-.2	-.2	1.1	-1.1	-1.1	-.8	
NGO	Count	0	3	18	2	0	1	24
	%	0.0%	12.5%	75.0%	8.3%	0.0%	4.2%	100.0%
	Residual	-1.3	.1	.9	.3	-1.0	-.8	
Research	Count	0	8	37	0	0	2	47
	%	0.0%	17.0%	78.7%	0.0%	0.0%	4.3%	100.0%
	Residual	-1.8	1.1	1.5	-1.8	-1.4	-1.1	
Aboriginal	Count	1	4	6	0	1	0	12
	%	8.3%	33.3%	50.0%	0.0%	8.3%	0.0%	100.0%
	Residual	.2	2.2	-.5	-.9	.7	-1.0	
Resident	Count	17	2	27	3	5	6	60
	%	28.3%	3.3%	45.0%	5.0%	8.3%	10.0%	100.0%
	Residual	6.4	-1.9	-1.6	-.5	1.5	.2	
Visitor	Count	11	34	156	20	10	28	259
	%	4.2%	13.1%	60.2%	7.7%	3.9%	10.8%	100.0%
	Residual	-1.6	.7	-.2	.7	-.3	.9	
Commercial fishing	Count	0	1	1	1	1	1	5
	%	0.0%	20.0%	20.0%	20.0%	20.0%	20.0%	100.0%
	Residual	-.6	.5	-1.2	1.2	1.7	.8	
Total		35	60	315	34	22	47	513
		6.8%	11.7%	61.4%	6.6%	4.3%	9.2%	100.0%

Table 3
Association of stakeholder ***interest*** with ***value orientation***. The overall association is significant ($\chi^2 = 98.1$, $df = 10$, $p < 0.001$) with standardized residuals less than −2.0 (pink) or greater than 2.0 (green) highlighted. Note: caution is warranted in interpreting results as 28% of cells have expected counts less than 5.

Value Orientation		Interest						Total
		Recreation	Aboriginal	Ecology	Tourism	Resources	Planning	
Environment	Count	13	43	290	16	8	28	398
	%	37.1%	65.2%	85.3%	44.4%	36.4%	54.9%	72.4%
	Std. Residual	-2.4	-.7	2.8	-2.0	-2.0	-1.5	
Balance	Count	18	13	34	14	12	15	106
	%	51.4%	19.7%	10.0%	38.9%	54.5%	29.4%	19.3%
	Std. Residual	4.3	.1	-3.9	2.7	3.8	1.6	
Economic	Count	4	10	16	6	2	8	46
	%	11.4%	15.2%	4.7%	16.7%	9.1%	15.7%	8.4%
	Std. Residual	.6	1.9	-2.3	1.7	.1	1.8	
Total	Count	35	66	340	36	22	51	550
	%	6.4%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Stakeholder *identity* was significantly associated with *value orientation* ($\chi^2 = 52.9$, $df = 16$, $p < 0.001$) with moderate strength of

Table 4
Association of stakeholder ***identity*** with ***value orientation***. The overall association is significant ($\chi^2 = 52.9$, df = 16, $p < 0.001$) with standardized residuals less than −2.0 (pink) or greater than 2.0 (green) highlighted. Note: caution is warranted in interpreting results as 44% of cells have expected counts less than 5.

Value orientation		Identity									Total
		Oil/gas	Tourism	Government	NGO	Research	Aboriginal	Resident	Visitor	Commercial fishing	
Environment	Count	7	20	54	22	40	8	34	178	2	365
	%	41.2%	80.0%	85.7%	91.7%	88.9%	66.7%	56.7%	69.0%	40.0%	71.7%
	Std. Residual	-1.5	.5	1.3	1.2	1.4	-.2	-1.4	-.5	-.8	
Balance	Count	8	3	8	2	4	0	19	53	3	100
	%	47.1%	12.0%	12.7%	8.3%	8.9%	0.0%	31.7%	20.5%	60.0%	19.6%
	Std. Residual	2.5	-.9	-1.2	-1.3	-1.6	-1.5	2.1	.3	2.0	
Economics	Count	2	2	1	0	1	4	7	27	0	44
	%	11.8%	8.0%	1.6%	0.0%	2.2%	33.3%	11.7%	10.5%	0.0%	8.6%
	Std. Residual	.4	-.1	-1.9	-1.4	-1.5	2.9	.8	1.0	-.7	
09Total	Count	17	25	63	24	45	12	60	258	5	509
	%	3.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

association (Cramer's V = 0.23, p < 0.001) (see Table 4). The standardized residuals indicate that participants with oil/gas (+2.5), resident (+2.1), and commercial fishing (+2.0) interests were significantly over-represented in the *balanced* value group, while Aboriginal (+2.4) interests were over-represented in the *economic* group.

3.3. Stakeholder values and preferences (non-place specific)

The non-place specific mapping behavior of stakeholder groups based on *identity*, *interests*, and *value orientation* were analyzed using chi-square and correspondence analyses. With respect to self-identified group, residents (n = 120) were more likely to map recreation values and preferences to increase recreation facilities, tourism stakeholders (n = 33) were more likely to map nature-based tourism values and preferences to limit oil/gas development, NGOs (n = 26) were more likely to map biological/conservation values and preferences to increase conservation protection, and government (n = 86) and research (n = 66) stakeholders were more likely to map biological conservation values and preferences to limit new port development (see Table 5). There were relatively few participants that self-identified with the commercial fishing (n = 5) and oil/gas industries (n = 19), but the mapped preferences of these participants were consistent with these identities, with commercial fishing stakeholders more likely to map preferences to increase commercial fishing and oil/gas stakeholders more likely to map preferences to increase oil/gas development. Stakeholders identifying as Aboriginal (n = 12) were less likely to map preferences to add tourism facilities and less likely to prohibit oil/gas development. Visitors (n = 343) were more likely to map recreational fishing values and less likely to map preferences for new port development.

Stakeholder *interests* that were significantly related to type and number of mapped values and preferences appear in Table 6. Stakeholders with *recreation* interests (n = 35) were more likely to map fewer nature-based tourism (−2.8), intrinsic (−2.1), Aboriginal culture (−3.2), biological (−4.1), and wilderness values (−4.4), and significantly more preferences to improve access (+2.2). Stakeholders identifying with *Aboriginal* interests were more likely to map fewer wilderness values (−2.1), while stakeholders with *ecological* interests were more likely to map intrinsic (+3.0), learning/research (+3.4), nature-based tourism (+3.4), Aboriginal culture (+4.1), biological (+6.1), and wilderness values (+6.3). Ecological interests were more likely to map preferences to limit new oil/gas (+3.1) and port development (+2.9), and to increase conservation (+5.5). *Tourism* interests were more likely to map preferences to add recreation facilities (+2.5) and improve access (+2.0), while *resource* interests were more likely to map fewer preferences to increase conservation (−2.3), increase Aboriginal management (−2.3), and to limit oil/gas (−3.0) and port development (−2.1). *Planning* stakeholder interests were more likely to map values for biological (+2.2) and recreational fishing (+2.0).

Stakeholder groups by value orientation were unevenly distributed between *environmental* (n = 406), *balanced* (n = 116), and *economic* (n = 51) priorities (see Table 7). *Environmental* stakeholders were more likely to map values of most types, especially biological (+6.9) and wilderness (+6.1) values, while the *balanced* and *economic* groups mapped fewer of the same categories of values. Stakeholder group propensities to map preferences were logically related to the types of values that were mapped. For example, *environmental* stakeholders were more likely to map preferences to restrict access, limit commercial fishing, and restrict new oil/gas and port development. The *balanced* group expressed the opposite pattern for mapped preferences. These results suggest a stronger pro-development perspective in the *balanced* group than the *environmental* group. The *balanced* group also appeared somewhat more pro-development than the *economic* group, a result inconsistent with what would be expected on the EEP scale.

Table 5
Stakeholder groups by ***identity*** that are significantly related ($p \leq 0.05$ yellow or $p \leq 0.10$ green) to the type and number of values and management preferences mapped. A chi-square test of independence was calculated for each stakeholder group in a 2 × 2 contingency table: group/non-group by mapped/non-mapped. Plus (+) indicates more individuals in the stakeholder group mapped than individuals not in the group while minus (−) indicates fewer individuals in the group mapped than others not in the group. P-values of the chi-square association are also reported.

Stakeholder identity	Values	Preferences
Resident (n=120)	Recreation (+) .001 Rec. fishing (+) .000	Add recreation facilities (+) .071 No commercial fishing (+) .009 New port development (+) .000 Other preference (+) .002
Aboriginal (n=12)		Add tourism services (-) .078 No oil/gas development (-) .070
Visitor (n=343)	Rec. fishing (-) .001	No oil/gas development (-) .089 New port development (-) .041 Other preference (-) .035
Commercial fishing (n=5)	Recreation (-) .074 Nature-based tourism (-) .043 Wilderness (-) .010	Commercial fishing (+) .021
Government employee (n=86)	Rec. fishing (+) .042 Biological/conservation (+) .007 European heritage (+) .077	No new port development (+) .091 Other preference (+) .074
NGO (n=26)	Scenic (+) .039 Biological/conservation (+) .025 Wilderness (+) .10 Special places (+) .070	Increase conservation (+) .001 Increase Aboriginal management (+) .036
Tourism (n=33)	Nature-based tourism (+) .085 Special places (+) .10	No oil/gas development (+) .012
Oil/gas (n=19)	Aboriginal culture (-) .096	Oil/gas development (+) .003
Research (n=66)	Recreation (-) .000 Rec. fishing (-) .000 Economic (non-tourism) (-) .093 Biological/conservation (+) .000 Therapeutic/health (-) .004	Restrict access (+) .085 No new port development (+) .026

Table 6
Stakeholder groups by ***interest*** that are significantly related to the type and number of values and management preferences mapped. Numbers in parentheses indicate significant standardized residuals (greater than +2.0 or less than −2.0) following a statistically significant chi-square association ($p \leq 0.10$) between the six stakeholder interests and a given value or preference. The sign of the standardized residual indicates more (green +) or fewer (yellow −) individuals in the stakeholder interest mapped than expected.

Stakeholder interest	Values	Preferences
Recreation (n=35)	Nature-based tourism (-2.8) Biological/conservation (-4.1) Aboriginal culture (-3.2) Intrinsic (-2.1) Wilderness (-4.4)	Increased conservation (-3.1) Improve access (+2.2)
Aboriginal (n=67)	Wilderness (-2.1)	
Ecological (n=343)	Nature-based tourism (+3.4) Biological/conservation (+6.1) Aboriginal culture (+4.1) Education/research (+3.4) Intrinsic (+3.0) Wilderness (+6.3) Special places (+3.1)	Increased conservation (+5.5) No oil/gas development (+3.1) New port development (-2.2) No new port development (+2.9)
Tourism (n=36)	Biological/conservation (-3.8) Aboriginal culture (-2.3) Wilderness (-2.5)	Add recreation facilities (+2.5) Improve access (+2.0)
Resources (n=22)	Biological/conservation (-2.7) Education/research (-2.5) Wilderness (-2.4)	Increased conservation (-2.3) Increased Aboriginal management (-2.3) No oil/gas development (-3.0) No new port development (-2.1)
Planning (n=51)	Biological/conservation (+2.2) Rec. fishing (+2.0)	

Table 7
Stakeholder groups by ***value orientation*** (environment/balanced/economic) that are significantly related to the type and number of values and management preferences mapped. Numbers in parentheses show significant standardized residuals (greater than +2.0 or less than −2.0) following a statistically significant chi-square association ($p \leq 0.10$) between the three stakeholder orientations and a given value/preference. The sign of the standardized residual indicates more (green +) or fewer (yellow −) individuals in the stakeholder orientation mapped than expected.

Stakeholder value orientation	Values	Preferences
Environmental (n=406)	Scenic (+3.5) Nature-based tourism (+3.4) Biological/conservation (+6.9) Aboriginal culture (+4.6) European heritage (+3.5) Intrinsic (+3.2) Wilderness (+6.1)	Increase conservation (+4.9) Increase Aboriginal mgmt. (+3.2) Add recreation facilities (-2.7) Restrict access (+2.2) Commercial fishing (-2.3) No commercial fishing (+2.5) Oil/gas development (-4.3) No oil/gas development (+5.4) New port development (-3.9) No new port development (+3.7)
Balanced (n=116)	Scenic (-2.2) Nature-based tourism (-2.7) Biological/conservation (-5.8) Aboriginal culture (-5.1) European heritage (-3.1) Intrinsic (-3.2) Wilderness (-5.4)	Increase conservation (-3.4) Increase Aboriginal management (-2.3) Add recreation facilities (+2.3) Restrict access (-2.3) Commercial fishing (+2.6) No commercial fishing (-2.0) Oil/gas development (+3.5) No oil/gas development (-4.8) New port development (+3.6) No new port development (-3.1)
Economic (n=51)	Scenic (-2.5) Biological/conservation (-2.9) Wilderness (-2.0)	Increase conservation (-3.0)

Correspondence analysis was used to generate normalized plots of the relationships between stakeholder groups defined by *identity* and *interests* and the categories of mapped values and preferences. Correspondence analyses of stakeholder groups by mapped preferences captured more of the total inertia or variance explained (*identity* = 20%, *interests* = 18%) than mapped values (*identity* = 12%, *interests* = 12%). With stakeholder *identity*, NGOs and research stakeholders were similar in their propensity to map biological/conservation values, Aboriginal stakeholders and residents were similar in mapping recreational fishing and special place values, and tourism and government stakeholders were similar in their propensity to map scenic, Aboriginal culture, nature tourism, and learning values (Fig. 3). Research, tourism, and Aboriginal stakeholders were similar in their propensity to map preferences to restrict oil/gas and new port development; visitors had greater propensity to map preferences to increase recreation facilities, tourism development, access, and Aboriginal management; and NGOs had greater propensity to map preferences for increasing conservation and Aboriginal management. Commercial fisherman and oil/gas stakeholders were differentiated from the other stakeholder groups in their propensity to map preferences for increasing commercial fishing and new oil/gas development respectively.

The normalized plots of stakeholder groups by *interests* are provided in Fig. 4. Stakeholders with interests in resources and recreation were differentiated from other interests in their

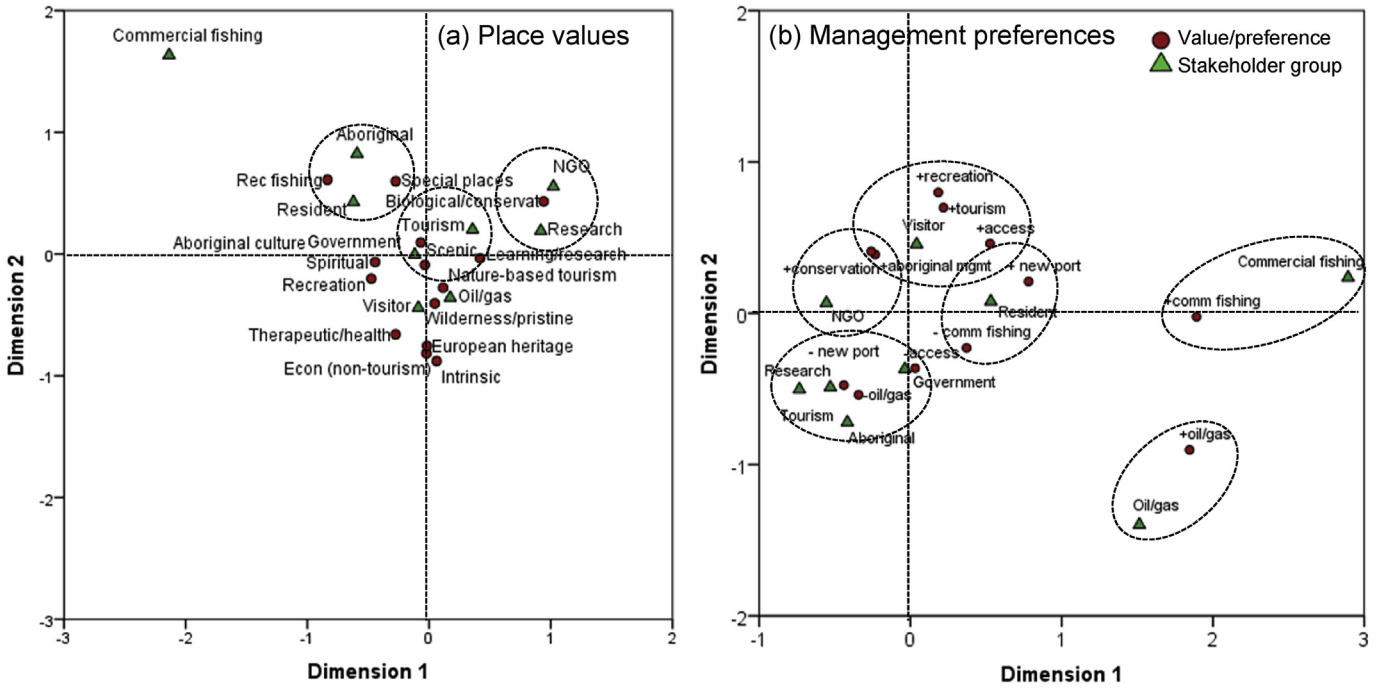

Fig. 3. Correspondence analysis plots by ***self-identified stakeholder group*** by mapped: (a) place values and (b) management preferences.

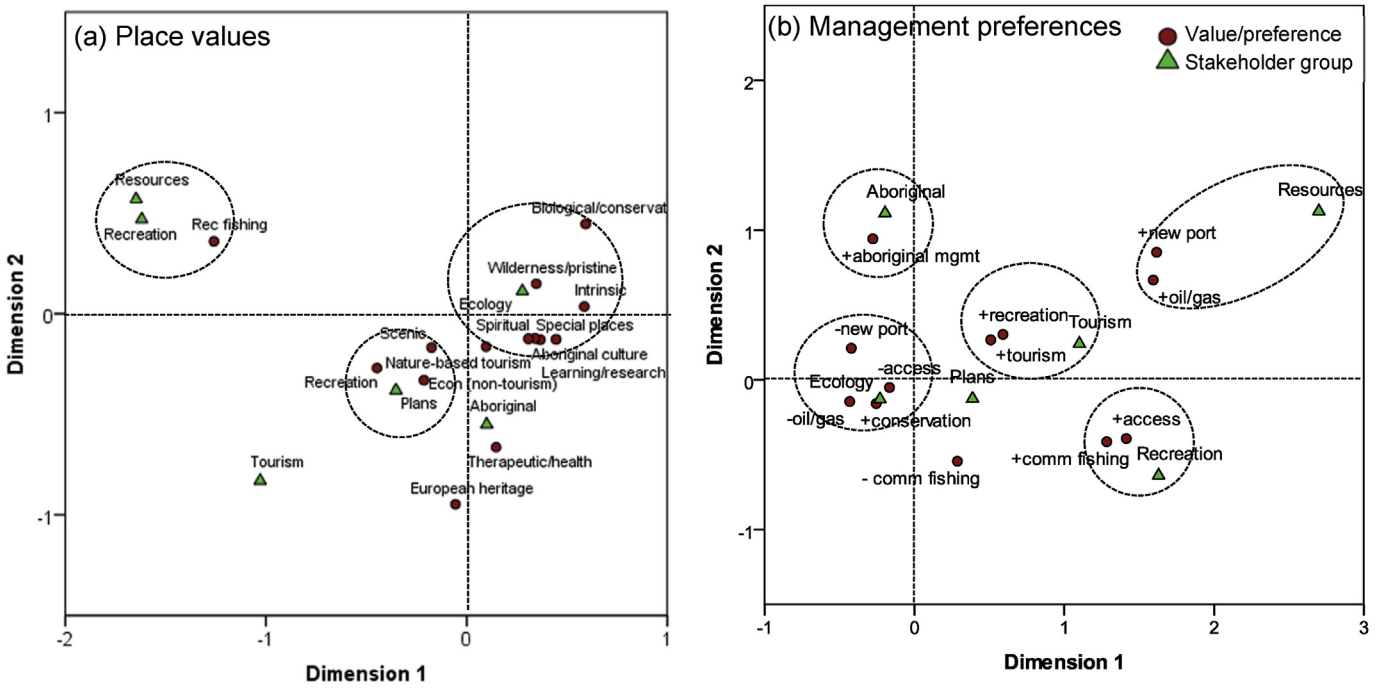

Fig. 4. Correspondence analysis plot of stakeholder groups by self-identified ***future interests*** with mapped: (a) place values and (b) management preferences.

propensity to map recreational fishing value, while planning interests were most closely associated with the mapping of scenic, economic (non-tourism), and recreation values. Ecological interests were associated with the mapping of wilderness, biological, intrinsic, spiritual, Aboriginal culture, and special place values. With respect to mapped preferences, there were clearer associations by stakeholder interests. Resource interests were associated with the mapping of preferences for new oil/gas and port development, recreation interests were associated with the mapping of increased access and commercial fishing, Aboriginal interests were associated with mapped preferences to increase Aboriginal management in the region, tourism interests were associated with preferences to increase tourism development and recreation facilities, and ecological interests were associated with preferences to limit access and all types of development while increasing conservation.

3.4. Stakeholder preferences by MPA

The frequency distribution of mapped preferences for all study participants for the five proposed MPAs in the region appears in Fig. 5. The number of preferences ranged from n = 1133 in the proposed North Kimberley MPA to n = 155 in the proposed Eighty Mile Beach MPA. The distribution of profiles was very similar for the northern MPAs (North Kimberley, Horizontal Falls, and Camden Sound/Lalang Garram) with the largest number of preferences for increased conservation and restricting commercial fishing and oil/gas. The southern MPAs (Roebuck Bay and Eighty Mile Beach) had somewhat greater proportions of preferences, relative to the northern Kimberly MPAs, of increasing recreation facilities and access.

The frequency distributions of preferences were generated for the North Kimberley and Roebuck Bay proposed MPAs using the stakeholder classifications for *identity* and *interests* (Figs. 6 and 7). The frequency distributions of preferences for the North Kimberley proposed MPA by *identity* indicate that *NGO*, *tourism,* and *visitor* stakeholders strongly emphasized conservation preferences in this area. *Research* stakeholders placed greater emphasis on Aboriginal management and decreased access than other stakeholder groups. The mapping of preferences in the North Kimberley by *oil/gas* stakeholders emphasizing the restriction of new oil/gas and port development may appear counter-intuitive. However, these results warrant caution in interpretation given that mapped preference data for oil/gas stakeholders was quite limited overall. Further, it is noteworthy that the largest percentage of participants by oil/gas *identity* identified with ecology *interests* (see Table 2).

In the North Kimberley, there were some differences in the relative proportions of preferences mapped by stakeholder *interests*. Participants identifying with *resources* placed greater emphasis on new port development while participants identifying with Aboriginal interests placed greater emphasis on Aboriginal management. Stakeholder interests associated with *planning*, *tourism*, and *recreation* placed greater emphasis on increasing recreation facilities than the other groups (see Fig. 6). In the Roebuck Bay proposed MPA, preferences for conservation were dominant among stakeholder interests with *tourism* and *recreation* interests showing stronger preferences for increased access (see Fig. 7).

The frequency distributions of preferences for the two proposed MPAs by *identity* indicate that *NGO* and *tourism* stakeholders strongly emphasized conservation preferences in the North Kimberley while *residents* strongly emphasized conservation preferences in Roebuck Bay. (see Figs. 8 and 9). *Research* stakeholders placed greater emphasis on Aboriginal management and decreased access in both proposed MPAs than other stakeholder groups. In Roebuck Bay, *visitors* placed greater emphasis on increased recreation facilities and access. The mapping of preferences in the North Kimberley by *oil/gas* stakeholders that emphasized the restriction of new oil/gas and port development may appear counter-intuitive. However, these results warrant caution in interpretation given that mapped preference data for oil/gas stakeholders was quite limited overall with no mapped preferences in Roebuck Bay.

4. Discussion

We have presented a method for conducting stakeholder analysis for marine conservation planning by operationalizing multiple definitions for stakeholder groups based on *identity*, *interests*, and *value orientation*. These stakeholder classifications were significantly associated, with stakeholder *identity* logically related to stakeholder *interests* in the study region. Stakeholder groups showed significantly greater propensity for mapping certain types of values and preferences related to their *identity*, *interests*, or *value orientation*. Analysis of mapping behavior of stakeholder groups in proposed MPAs in the Kimberley region revealed that management preferences can be differentiated based on stakeholder *identity* or *interests*. The implications for marine conservation and future PPGIS efforts are explored in the following two sections.

4.1. Marine conservation planning implications

The operational method for identifying stakeholder groups affects what values and preferences are mapped. Although we found a statistical association between self-identified stakeholder *identity* and *interests,* the association was not strong, resulting in mapping differences between *identity* and *interests*. For example,

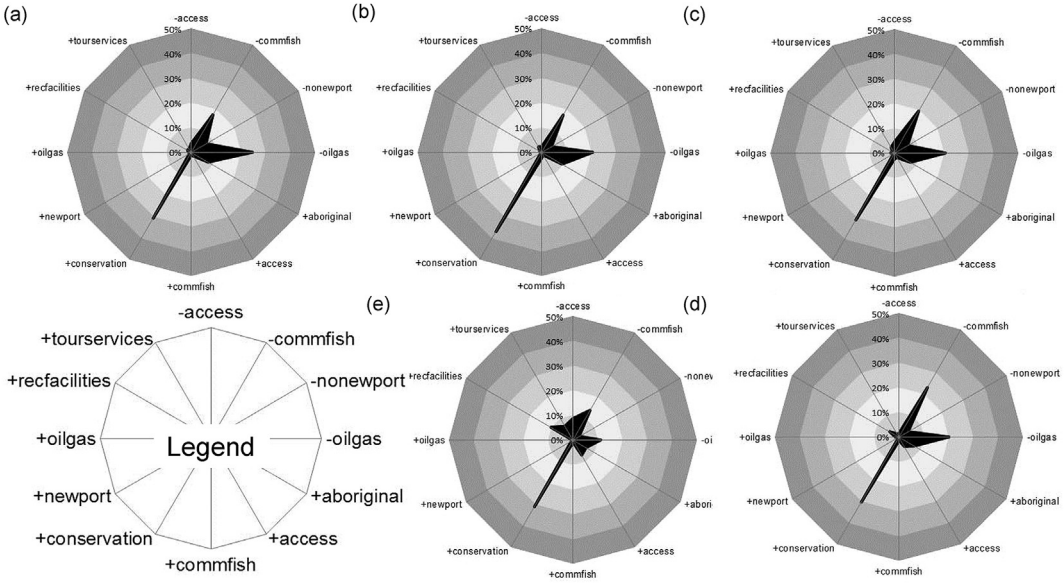

Fig. 5. Mapped management preferences by category (%) for all participants in proposed marine parks in the Kimberley region: Clockwise from left to right: (a) North Kimberley (b) Horizontal Falls (c) Camden Sound (d) Roebuck Bay (e) Eighty Mile Beach.

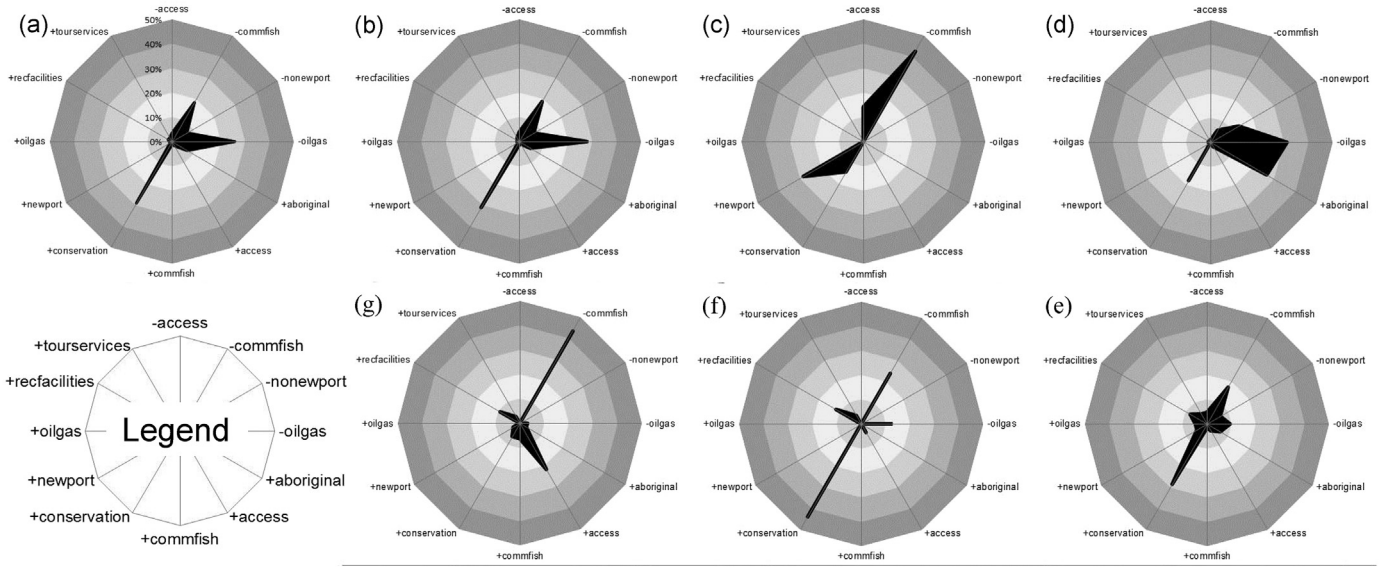

Fig. 6. Mapped management preferences by category (%) in the proposed North Kimberley Marine Park by ***stakeholder interest groups***. Clockwise from left to right: (a) all groups (b) ecology (c) resources (d) Aboriginal (e) planning (f) tourism (g) recreation.

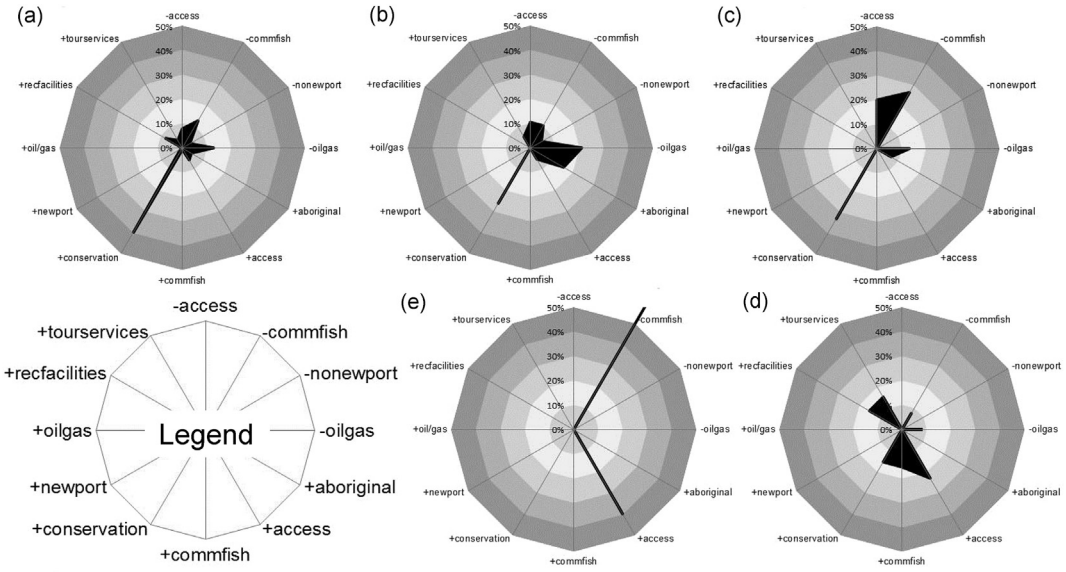

Fig. 7. Mapped management preferences by category (%) in the proposed Roebuck Bay Marine Park by ***stakeholder interest groups***. Clockwise from left to right: (a) ecology (b) Aboriginal (c) planning (d) tourism (e) recreation.

participants that *identify* with the tourism industry disproportionately mapped preferences in opposition to oil/gas development, but participants expressing future *interests* in tourism mapped disproportionately more preferences for adding recreation facilities and increasing access. This occurred because only a small proportion (16%) of participants that self-identified with tourism indicated their primary future interest in the region to be tourism (see Table 2). The majority of tourism stakeholders by *identity* were not the same individuals expressing tourism *interests*. These stakeholder classification differences can manifest in different planning priorities for proposed MPAs. Tourism stakeholders by *identity* and *interests* mapped similar priorities for the North Kimberley MPA, but the Roebuck Bay MPA mapping outcomes were different, with tourism *identity* stakeholders prioritizing increased conservation, and tourism *interest* stakeholders prioritizing increased access. From a marine planning perspective, these differences may be important depending on whether increased access is considered compatible or incompatible with increased conservation.

An important, but under-researched topic in marine conservation planning is the influence of agency planners, policy makers, and managers on planning outcomes. The majority of participants that identified with the government stakeholder group expressed their future interests in the Kimberley as *ecological* (Table 2, 72%), with few individuals ($n = 4$) indicating their future interests in the Kimberley to be *planning*. The largest stakeholder group by *identity* that expressed *interest* in marine planning was visitors, but these visitors are unlikely to hold formal positions with direct influence over MPA planning outcomes. In this case, the implications for marine planning are best viewed through participants having both

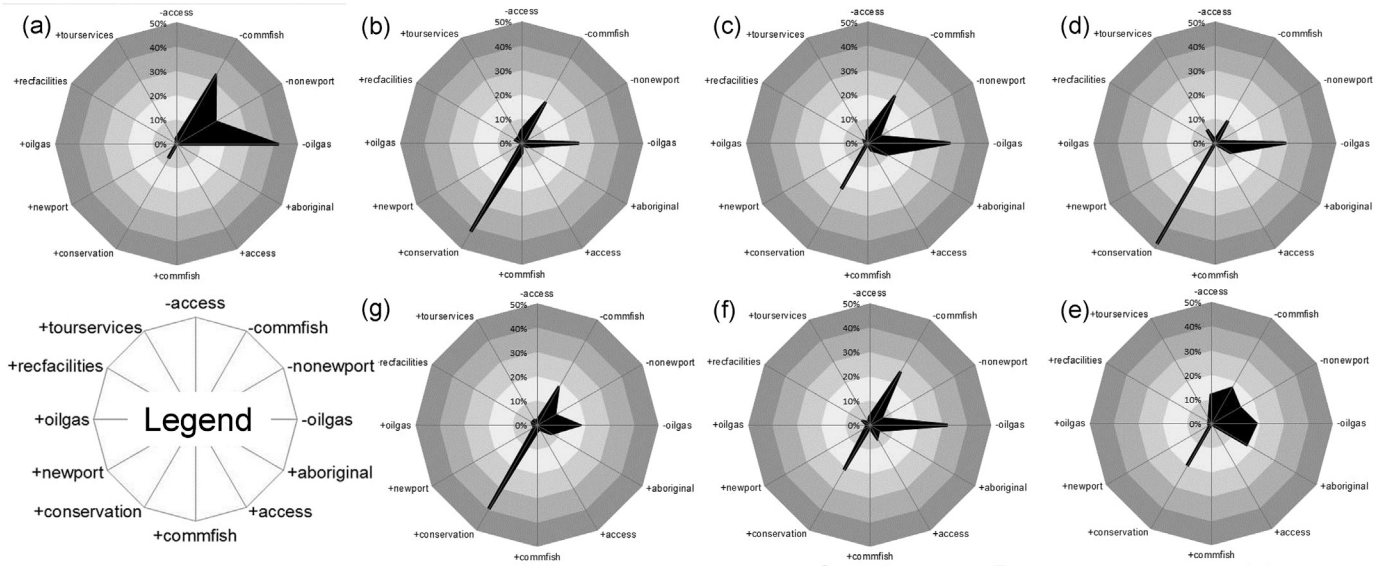

Fig. 8. Mapped management preferences by category (%) in the proposed North Kimberley Marine Park by ***stakeholder identity groups***. Clockwise from left to right: (a) oil/gas (b) tourism (c) government (d) NGO (e) research (f) resident (g) visitor.

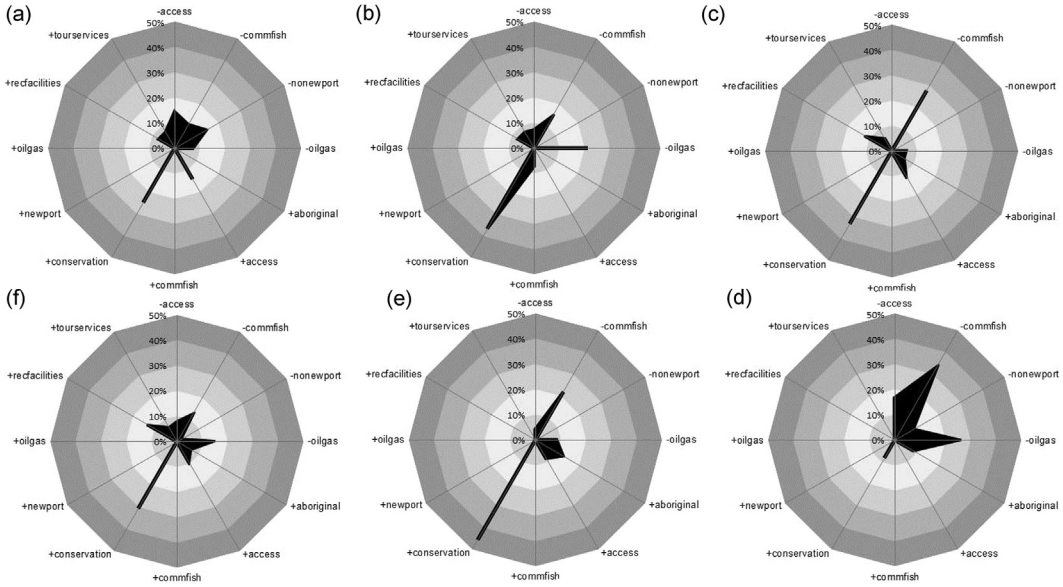

Fig. 9. Mapped management preferences by category (%) in the proposed Roebuck Bay Marine Park by ***stakeholder identity groups***. Clockwise from left to right: (a) tourism (b) government (c) NGO (d) research (e) resident (f) visitor.

government *identity* and as well as planning *interests*, but the small number of participants meeting these criteria (n = 4) exposes a limitation of the methods described herein. These four individuals may be highly influential in MPA planning within government, but there is no way to determine their identity or relative decision influence. Further, spatial mapping with points, as was done in this study, requires relatively large sample sizes to make valid inferences about spatial locations. With smaller sample sizes, the use of polygons for spatial mapping may be more appropriate (Brown & Pullar, 2012). Thus, while the small number of stakeholders that identify with both *government* and *planning* interests appear supportive of conservation with opposition to resource development in the two proposed MPAs examined, these results require more information about the participants for meaningful interpretation.

In marine conservation planning, *recreation* and *ecology* interests are often assumed as having little in common. However, this assumption is usually made with little or no supporting data. In this study, there was empirical evidence showing different mapped values and preferences by recreation and ecology interests (see Table 6), resulting in different planning priorities in the two proposed MPAs (see Figs. 6 and 7). Conservation interests were most concerned with restricting resource development activities while recreation interests were most concerned with increasing access. Understanding these differences early in the marine planning process is essential to address latent interests that can thwart effective planning outcomes.

Analyzing stakeholder mapping data at different geographic scales and levels of data aggregation provides different insights for marine conservation planning. While our final analysis focused on specific, proposed MPAs in the study region, there is also value in

examining whole region and aggregated results. When the mapped preferences for all participants were combined, preferences for marine conservation dominated as illustrated in Fig. 5. We surmise this result reflects strong engagement by conservation interests in this study (i.e., 71% of participants expressed an environmental value orientation). This level of engagement may reflect the highly politicized process of marine conservation planning in the Kimberley region where conservation efforts have recently emerged and galvanized to oppose a proposal for major offshore gas development and associated land-based infrastructure. Thus, the timing of a participatory mapping process relative to important external events can strongly influence the type of people that participate and thus, the mapped results.

A comparative analysis of management preferences across the five MPAs using radar plots (Fig. 5) demonstrates the usefulness of such plots for identifying potential regional differences in desired planning outcomes. For the two more accessible MPAs close to Broome (Roebuck Bay and Eighty Mile Beach), increasing access and recreation facilities were more favored than for the three more remote MPAs. This comparative analysis provides a means for marine planners to identify and potentially tailor MPA management options based on regional differences. MPAs located near larger human settlements will likely require greater flexibility in managing the MPAs to accommodate a wider range of human uses.

4.2. Stakeholder analyses and future PPGIS efforts

A facile conclusion of our findings would be that stakeholder group affiliation, whether through *identity* or *interests*, determines what values and preferences people are likely to map in participatory GIS. For example, NGOs representing environmental values were strongly supportive of conservation while restricting resource development, commercial fisherman favored commercial fishing activity, and oil/gas stakeholders favored oil/gas development. However, the data and conclusions from this study appear more nuanced. For example, stakeholders identifying with the oil/gas industry expressed less value for Aboriginal culture, research stakeholders expressed less value for recreational and therapeutic values that derive from increased access to remote areas, and visitors expressed less value for recreational fishing despite being marketed as a regional attraction.

The identification of stakeholder identity using *value orientation* provided limited explanatory power, the likely result of social desirability bias in participant EEP scale responses. Stakeholders with resource development interests were more likely to select a *balanced* value orientation over *economic* prioritization. The other stakeholder operational definitions, *identity* and *interests*, provided better insight into mapped preferences for marine conservation. There was greater propensity for participants that *identified* or expressed *interests* in resources to map more development preferences for oil/gas and port development, and these general mapping propensities were evident in place-specific, proposed MPAs. Participants identifying with environmental NGOs or expressing ecological interests had greater propensity to map conservation and anti-resource development preferences which also manifested in proposed MPAs. These results support the findings of Brown (2013) that non-spatial values of participants can manifest in behavioral choices when mapping place-specific values and preferences, and that volunteer sampling, in particular, can result in biased perspectives toward resource use and environmental protection compared to random sampling methods (Brown, Kelly, & Whitall, 2014). Knowing which particular stakeholder groups and interests participated in the mapping activity appears to be critical information for determining how to aggregate and potentially weight responses for determining the acceptability of new proposed MPAs.

We described the final step in stakeholder analysis using participatory mapping as place-based integration for decision support. But what does this mean? As observed by Weible (2007) in the context of MPAs, this means going beyond technical analysis and engaging in political analysis. A common stakeholder analysis method identifies and maps stakeholders in two-dimensional space consisting of power/influence by level of interest (Bryson, 2004). However, stakeholder analysis using PPGIS does not explicitly assess stakeholder power or influence. Further, whereas traditional stakeholder analysis usually focuses on a single alternative (Ramirez, 1999; Susskind & Thomas-Larmer, 1999), participatory mapping provides stakeholder information on multiple preferences and futures, and in this study, multiple MPAs. Volunteer sampling, as undertaken in this study, can result in biased perspectives toward resource use and environmental protection compared to random sampling methods (Brown et al., 2014; Brown, in press).

Brown et al. (2015) described methods for modeling stakeholder agreement and disagreement in multiple, place-specific locations to inform management decisions and emphasized the need for research that provides critical insight into stakeholder dynamics, power relations, and perceptions of influence over government officials responsible for decision-making. The integration of such information with participatory mapped spatial data is needed to progress the utility of PPGIS in decision support. Without this information, the weightings idealized in Fig. 1 can only be provided through speculation about power relations that may not reflect reality.

A potential approach to the vexing issue of stakeholder weighting would be to conduct a representative survey of Australian residents to determine how their values and preferences align (or not) with the different stakeholder perspectives identified in this study. The results of the survey could be used to derive stakeholder weights for aggregating preferences for proposed MPAs in the region. However, one important limitation with this approach is the different ontological assumptions underpinning such a survey and PPGIS. A general survey is likely to evoke responses that are place-independent, eliciting responses from individuals potentially unfamiliar with the marine and coastal environments of the study region. In contrast, PPGIS is underpinned by the ontological assumption that participants are providing responses based on some place familiarity.

In the absence of political analysis or a survey of Australian residents, the default position for stakeholder analysis using participatory mapping methods assumes that stakeholders are similar in importance and influence, and accordingly, their mapped values and preferences can be aggregated and interpreted without weighting. We would consider this approach politically naïve given the highly contentious nature of marine conservation in Australia and elsewhere. In the case of the Kimberley region, the aggregated, unweighted responses of stakeholder groups do not suggest strong conflict over the proposed MPAs. The coastal and marine values, as well as management preferences, were strongly supportive of conservation as a priority. However, commercial fishing interests were largely absent from the participatory mapping process where they often present the most vocal opposition to MPAs, although the level of opposition will depend on the actual zoning of the MPA and whether the MPA is designated as a “no-take” area. The Kimberley region does have offshore oil/gas development potential, but the near-shore location of the proposed MPAs in state waters make oil/gas development less politically feasible in the region, with the mapped results reflecting this current political position.

Despite efforts to engage resource development interests in the participatory mapping process, the largely volunteer sampling and

recruitment resulted in participants that were demographically biased toward younger and more highly educated individuals, and importantly, toward mapped values and preferences that favor coastal and marine conservation. The extent of influence of this latter bias is unknown. The level of engagement by commercial fishing (n = 5) and oil/gas (n = 19) interests in this study was low relative to expectations regarding engagement by these stakeholders in other jurisdictions in Australia. However, the absence of commercial fishing interests from the participatory mapping process probably reflected the relatively small number of commercial fishing operations in the region relative to the eastern seaboard of Australia where such interests have been vocal opponents to MPA designation. And, although the Kimberley region has considerable oil/gas reserves, their offshore location relative to the nearshore location of the proposed MPAs in State waters means any controversy over this activity is less likely to be reflected in this study.

Whether stakeholders are "latent" or "definitive" (likely to seek political influence on planning outcomes) (Mitchell et al., 1997) matters in terms of possible weightings of values and preferences in PPGIS. In this study, the largest group of stakeholders by *identity* consisted of visitors who are best described as latent stakeholders. More definitive stakeholders such as commercial fishing and oil/gas interests are likely to demonstrate political influence far beyond what their participatory mapping engagement in this study would suggest.

5. Conclusion

Crowd-sourcing methods using PPGIS can result in better planning decisions (Brown, 2015) with the quality of these decisions enhanced by understanding how stakeholder identification methods influence interpretation of the results. Even knowing which particular stakeholder groups and interests participated in the mapping activity is critical information for determining how to aggregate information on proposed MPAs. The value of stakeholder identification using *value orientation* is questionable given it provided limited explanatory power, a likely result of social desirability bias in participant EEP scale responses.

Two major challenges require research and practitioner attention. The first is how to ensure a full suite of stakeholder engagement beyond conservation interests, which is essential if PPGIS is to be a credible, defensible approach to social data collection and analysis. Second, and probably more important, is being able to weight or use other means to include consideration of the relative power of stakeholders, their perceptions, and the perceptions of those involved in, and leading decision making (e.g., elected officials, government employees).

This is one of the first studies to report on the use of participatory mapping methods (PPGIS/PGIS/VGI) with the aim of informing marine spatial planning. This is not surprising given that participatory mapping to inform terrestrial conservation is relatively recent as well. The application of PPGIS methods is a response to increasing calls for social research to inform MPA planning and management (Gruby et al., 2015; Voyer et al., 2012). As these authors attest, the barriers to the inclusion of social science, including PPGIS, are more political than technical. Voyer et al. (2012) note the continuing barriers to effective public participation, while Gruby et al. (2015) make a more fundamental plea regarding inclusion of social dimensions in research for large MPAs. As part of a large multidisciplinary research program designed to inform management, this study has the potential to contribute significantly to the planning for Kimberley MPAs. As such, the story for the Kimberley coastal region is still being written.

Acknowledgments

The time and expertise contributed by the people who participated in this project are acknowledged. Without their generosity, this research would not have been possible. The interest and support of the Department of Parks and Wildlife and the 120 individuals, formal and informal groups who were involved in recruitment are also gratefully acknowledged. This research was supported by the Kimberley Marine Research Program, administered by the Western Australian Marine Science Institution.

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