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REPORT

# The role the Great Barrier Reef plays in resident wellbeing and implications for its management

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**Abstract** Improvements in human wellbeing are dependent on improving ecosystems. Such considerations are particularly pertinent for regions of high ecological, but also social and cultural importance that are facing rapid change. One such region is the Great Barrier Reef (GBR). Although the GBR has world heritage status for its 'outstanding universal value', little is known about resident perceptions of its values. We surveyed 1545 residents, finding that absence of visible rubbish; healthy reef fish, coral cover, and mangroves; and iconic marine species, are considered to be more important to quality of life than the jobs and incomes associated with industry (most respondents were dissatisfied with the benefits they received from industry). Highly educated females placed more importance on environmental non-use values than other respondents; less educated males and those employed in mining found non-market use-values relatively more important. Environmental non-use values emerged as the most important management priority for all.

**Keywords** Australia · GBRWHA · IDS · Perceptions · Quality of life · Values

## INTRODUCTION

Natural resource management agencies, regional planners, and other decision makers are facing increased pressure to address the social dimensions of resource management (Larson 2009). Having a better understanding of people's subjective wellbeing, and the most effective means of enhancing it, is thus playing an increasingly recognized role in policy and decision-making (Marans 2003). The current focus on wellbeing is thought to have increased awareness and recognition of the combined effects of social, economic, and environmental aspects of change and helped promote a more holistic approach to policy-making (Summers et al. 2012). Research that sheds light on the link between natural resources and subjective human wellbeing is thus becoming increasingly important both internationally (Layard 2005; MA 2005; Costanza et al. 2007; Summers et al. 2012) and in Australia (Cummins et al. 2003; Larson 2010a; Larson et al. 2013b).

Interest in human wellbeing from the natural resource management perspective has been derived largely through the popularization of the Millennium Ecosystem Assessment methodologies (MA 2005). In this context, wellbeing improvements are viewed as being dependent on improving ecosystem management and ensuring conservation and sustainable use of resources (MA 2005). Thus, better understanding of the relative importance of different aspects of wellbeing allows for more targeted operationalization of natural resources management strategies and the potential ecosystem trade-offs, in a way that is meaningful to the general community (Larson 2009). Such considerations are particularly pertinent for regions of high ecological, but also social and cultural importance that are facing rapid change.

One such region is the Great Barrier Reef (GBR) region, declared a World Heritage Area in 1981 because of its 'outstanding universal value'. The Great Barrier Reef World Heritage Area (GBRWHA) encompasses over 348 000 $km^2$ and extends for more than 2300 km along Australia's northeast coast. This area is not limited to reefs but also includes islands, beaches, estuaries, mangroves, and other parts of the marine system (Fig. 1).

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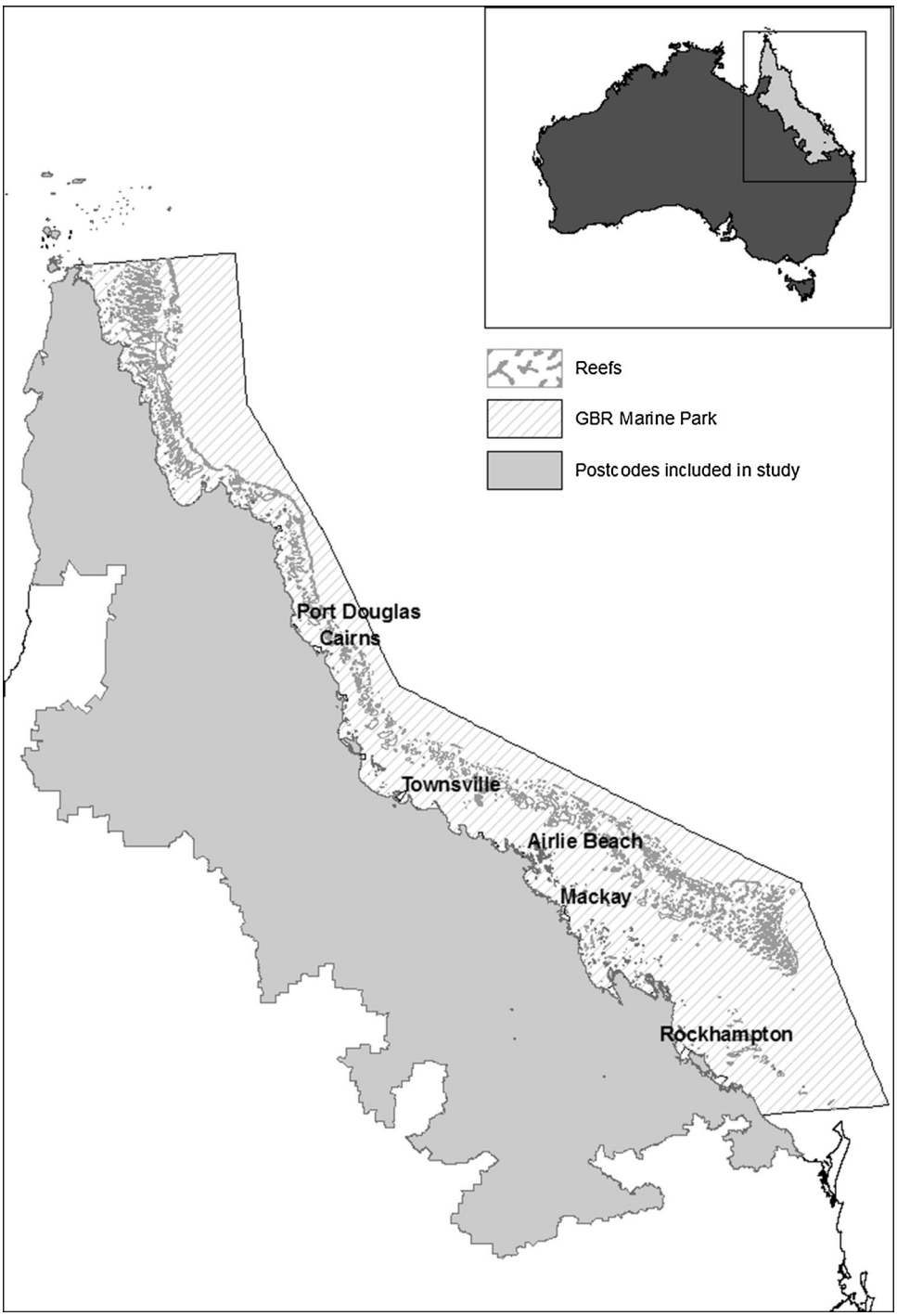


**Fig. 1** The Great Barrier Reef World Heritage Area, with coastal local government areas

The catchments that flow into the Great Barrier Reef lagoon cover an area of 424 000 square kilometers and the population of the region, which exceeds one million, is rising rapidly. Key industries in the region are mining and mineral processing, tourism and agriculture, generating annual contributions to the regional economy of thirteen, four and two billion Australian dollars, respectively (Access Economics 2007; Rolfe et al. 2011).

However, all this economic activity has not come without cost: since European settlement, there have been measurable increases in sediment, nutrient and pesticide loads in the GBR lagoon (Kroon et al. 2012), resulting in reef degradation (Brodie et al. 2012), chronic large-scale eutrophication (Bell et al. 2014) and precipitous declines in coral cover (De'ath et al. 2012). Indeed, recent rapid industrial growth and the resulting anthropogenic changes

and risks, have prompted the World Heritage Committee, at its meeting in June 2013, to express concerns for the future of the GBRWHA. UNESCO has asked Australia to ensure that the property remains well protected (UNESCO 2013), and has considered placing the GRBWHA on the List of World Heritage in Danger.

Although the GBR has been recognized as of 'outstanding universal value', little is known about the values residents of the region associate with the GBRWHA. For instance: What role does the GBRWHA play in the well-being of the local residents? Which aspects (values derived from the GBR) are important to the wellbeing of local residents, and how satisfied are they with them at present?

These questions provide focus for the first part of our paper: using data collected from a survey of more than 1500 residents of the GBR catchment area, we assess the 'importance' to overall quality of life and wellbeing, of a range of values that residents associate with the GBRWHA. We also assess their current level of satisfaction with those values. We then calculate Larson's Index of Dissatisfaction (IDS) for each value (Larson 2010a, 2011), using insights from it to identify a 'priority' list of items most in need of policy attention.

Previous research has shown that socio-demographic characteristics of people influence their wellbeing choices. Thus, in the second part of our paper, we look at the way in which resident perceptions about the contribution that various ecosystem services make to wellbeing relate to socio-demographics and discuss the potential implications of this for managers and policy makers.

## MATERIALS AND METHODS

### Data collection

Data were collected using a mail-out survey to a geographically stratified random sample of resident households in postcodes that lay partially or entirely within the study area. The pilot stage included survey of 230 randomly selected households (two from each of the postcodes identified), while the main mailing included about 40 households in each postcode. Following the Dilman (2007) methodology, we sent a reminder letter with replacement questionnaire to those who had not responded 4 weeks later, with a third reminder after that. We estimate that just under 4000 questionnaires reached their intended recipients, and we received 902 completed questionnaires.

We were cognizant that some demographic groups are more likely to respond to mail-out surveys than others (e.g., young males, Indigenous people) in these regions (Zander and Straton 2010). Therefore, we conducted supplementary face-to-face data-collection using the same questionnaire, across various public locations such as ferry terminals, airports, and beaches. These extra activities generated an additional 663 responses, bringing the total number of completed resident questionnaires to 1565, with 1546 having sufficient information to be used in the analysis reported here.

Our final sample (Electronic Supplementary Material, Table S1) was representative of the population in the region in terms of geographic distribution, gender, indigenity, and those employed in the mining and manufacturing, government agencies and tourism sectors (Government Statistician 2013). The sample over-represented those within the 45–64 year age group (45 % of sample compared to 32 % of population), those with a university degree (31 % compared to 16 % of the population), and those employed in agriculture, fishing and forestry sector (14 % of our sample, compared to 5 % of regional employees).

### Survey questions and methods of analysis

A survey instrument included both questions reported in this paper, and additional questions reported elsewhere.[1]

To provide data for exploration of our first research question, respondents were asked how important each of the items presented in Table 1 was to their overall well-being and quality of life, and how satisfied they currently were with each item. To avoid response bias, 24 different versions of the survey, with importance and satisfaction questions presented in a different order, were mailed, ensuring equal geographic coverage of each version.

The items listed in Table 1 were selected and defined during focus group discussions (FGD) with 'key informants' (i.e., individuals selected on the basis of their specific knowledge and understanding). They included representatives of government agencies, NGOs and citizen groups, industry groups and academics/experts with a stake in the GBRWHA. In the first round, attended by a total of 31 participants across three FGDs, the objectives of the study and relevant concepts were introduced, and an initial list of values was generated. Lists from these FGDs were

[1] The main aim of the project was to improve understanding of the relationship between the socioeconomic system and the GBRWHA, specifically, to improve understanding of resident views about the relative 'value' of key ecosystem services that are provided by the GBRWHA. Thus, the core sections of resident questionnaire included questions about: (1) The socio-demographic background of respondents; (2) Residents' activities and frequency of activities within the GBRWHA; (3) The importance of various values related to the GBRWHA to overall wellbeing and quality of life and satisfaction with the current state of these values; (4) Perceptions about the way in which overall quality of life would be affected by changes in various environmental and market factors; and (5) Willingness to pay (WTP) for improvements in various environmental attributes of the GBRWHA. Please refer to Stoeckl et al. (2013) for more details on the survey instrument and its development.

**Table 1** Values related to the Great Barrier Reef World Herriate Area (GBRWHA) selected and defined during the FGD (in brackets, abrevisations used in this paper)

| |
|---|
| Benefiting from the jobs and income linked to: |
| The reef-based tourism industry (tourism) |
| The commercial fishing sector (commercial fishing) |
| The mining and agricultural sectors (mining/agriculture) |
| Benefiting from low prices associated with cheap shipping transport (cheap shipping) |
| Being able to: |
| Eat fresh locally caught seafood (seafood) |
| Go fishing, spear-fishing or crabbing (fishing) |
| Spend time on the beach, go swimming, diving, etc. (beach/swimming) |
| Go boating, sailing or jet-skiing (boating) |
| Having: |
| Undeveloped and uncrowded beaches and islands (undeveloped) |
| Beaches and islands without visible rubbish (bottles, plastic) (no rubbish) |
| Healthy coral reefs (coral reefs) |
| Healthy reef fish (reef fish) |
| Iconic marine species (whales, dugongs, turtles) (iconic species) |
| Clear ocean water (with good underwater visibility) (clear ocean) |
| Healthy mangroves and wetlands that clean polluted water from the land (mangroves) |
| Protecting traditional/indigenous cultural values (indigenous) |
| Preserving the GBRWHA either for its own sake or for future generations (future generations) |
| "Bragging rights"—being able to say "I live near the Great Barrier Reef" (bragging) |

then collated and presented back to participants in the next round (three FGDs with the total of 42 participants). The resulting list was further tested for its suitability and relevance with the randomly selected sample of 120 residents, to arrive at the final collapsed list of values presented in Table 1.

A five-point Likert scale ranging from very unimportant (−2) through to very important (2) was used. Respondents were also asked how satisfied they were with the state of each value, on the same scale. These data were first analyzed to establish the importance of and satisfaction with each value. Distributions were compared using Kruskal–Wallis non-parametric tests.

The IDS, a method for integrating information about the perceived importance of wellbeing contributors, with information about satisfaction with those contributors (Larson 2010a, 2011) was used to create an 'Action List' of wellbeing factors that might warrant attention from the decision and policy makers. This non-dollar denominated, point-based, stated preference technique allows one to compare both market and non-market values and has been previously tested and used to assess the contribution of the natural environment to wellbeing in several different Australian contexts (Larson et al. 2013a, b).

Formally, the IDS for wellbeing contributor $k$ ($IDS_k$) is calculated as:

$$IDS_k = I * DS * \frac{n_k}{N},$$

where $I$ is importance, DS is dissatisfaction (the inverse of satisfaction ($S$), here calculated as $2 - S$), $n_k$ is the number of respondents who reported both satisfaction and importance scores for contributor $k$, and $N$ is the total number of respondents.

For the second part of our analysis, we looked at the relationship between various socio-demographic characteristics of respondents and their 'importance' and IDS scores. Since importance scores were derived from Likert scale responses, we first estimated ordered logit models. However, the proportional odds assumption did not hold implying that ordered logit coefficients were not equal. The variables did not have bimodal distribution indicating no split populations, so we explored other estimation options. Recognizing the inherent interrelations between values, we then used the seemingly unrelated regression (SUR) approach which has been shown to be superior to logit models in instances where systems are highly correlated (Zeebari et al. 2012). We conducted Breusch–Pagan tests for each system of equations, finding statistically

**Table 2** Factors created using PCA on importance scores, with factor loadings

| Environmental non-use values | Non-market use-values | Industry use-values | Indigenous culture | Recognition |
|---|---|---|---|---|
| Coral reefs (0.922) | Fishing (0.855) | Mining/agric. (0.815) | Indigenous (0.745) | Bragging (0.739) |
| Reef fish (0.908) | Boating (0.831) | Cheap shipping (0.768) | | |
| Iconic species (0.885) | Time on beach (0.686) | Comm. Fishing (0.758) | | |
| Mangroves (0.836) | Seafood (0.629) | Tourism (0.576) | | |
| Clear ocean (0.801) | | | | |
| No rubbish (0.727) | | | | |
| Future gens (0.655) | | | | |
| Undeveloped (0.501) | | | | |

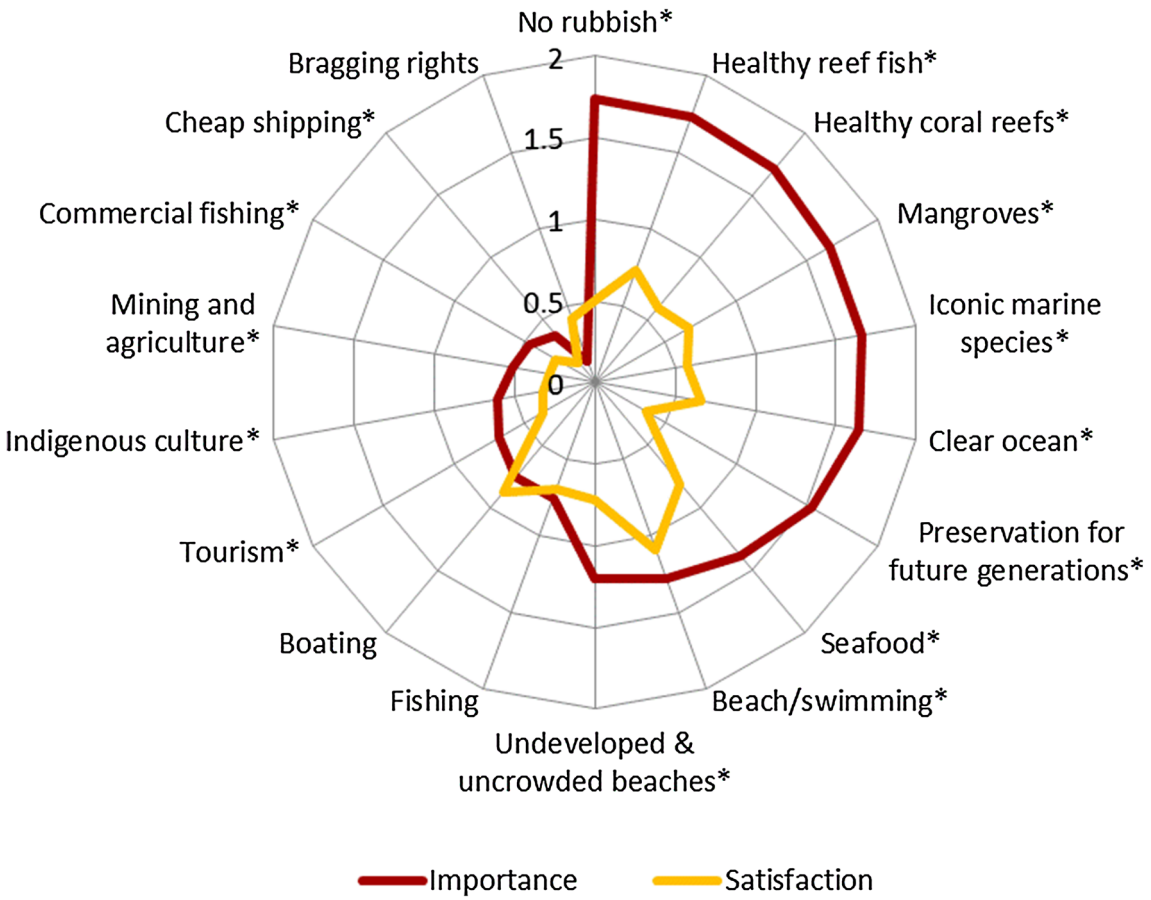


**Fig. 2** Perceived importance of and satisfaction with 18 values related with the GBRWHA (*statistically significant difference between distribution of responses to questions about importance and satisfaction)

significant evidence of those inter-relations. We thus further explored those relationships using principle component analysis (PCA) with Varimax rotation and Kaiser normalization, finding that our 18 values collapsed into five factors (Table 2)—the same factors for both importance and IDS scores. We then regressed each of these five factors (for importance, and then again for IDS) against variables measuring the socio-demographic characteristics of the respondents using stepwise ordinary least square (OLS) regression.

## RESULTS

### Importance of and satisfaction with aspects of GBRWHA

The five aspects selected by respondents as being the most important contributors to their wellbeing were, on average, beaches and islands without visible rubbish (mean score of 1.74); healthy reef fish (1.73); healthy coral reefs (1.71); healthy mangroves and wetlands that clean polluted water from the land (1.66) and iconic marine species such as whales, dugongs, and turtles (1.66) (Fig. 2; Table 3).

Satisfaction scores were significantly lower than importance scores for all values except boating, fishing and bragging rights (Fig. 2). Respondents were most dissatisfied with their (perceived) benefits from: low prices associated with cheap shipping (mean score of 1.89); the mining and agricultural sectors (1.77); the commercial fishing sector (1.76); the level of protection of traditional/Indigenous cultural values (1.73) and the chances that the GBRWHA will be preserved for future generations (1.64) (Table 3).

Using PCA, our importance scores for the 18 values assessed in this questionnaire collapsed into five factors presented in Table 2. Most of the values that load onto the first factor correspond with those which economists would likely term '*non-use values*'. Values included in the second and third factors are those which economists would term '*use-values*', with those in column two being mostly non-market use-values, and those in column three associated with the market/industry. Indigenous values and 'bragging rights' (being able to say that you live at specific address, specific city, or, in this case, a specific region) remained separate.

**Table 3** Action list of items most pertinent for management interventions along the GBRWHA, ranked by IDS score (importance and dissatisfaction are scored on −2 to +2 scale; % selecting are percentages of respondents who selected that value as important to their wellbeing; IDS score is a composite index calculated based on importance and dissatisfaction scores and % selecting)

| Rank value/factor | Importance | Dissatisfaction | % Selecting | IDS score |
|---|---|---|---|---|
| (1) No rubbish | 1.74 | 1.55 | 68.3 | 1.84 |
| (2) Future generations | 1.53 | 1.64 | 68.3 | 1.72 |
| (3) Iconic marine species | 1.66 | 1.47 | 67.6 | 1.65 |
| (4) Healthy coral reefs | 1.71 | 1.40 | 67.5 | 1.61 |
| (5) Healthy reef fish | 1.73 | 1.33 | 67.5 | 1.55 |
| (6) Healthy mangroves | 1.66 | 1.39 | 67.2 | 1.55 |
| (7) Clear ocean water | 1.64 | 1.34 | 67.2 | 1.48 |
| (8) Seafood | 1.38 | 1.17 | 67.4 | 1.10 |
| (9) Undeveloped and uncrowded beaches | 1.20 | 1.28 | 67.5 | 1.03 |
| (10) Spending time on the beach | 1.28 | 0.94 | 67.3 | 0.82 |
| (11) The reef-based tourism sector | 0.68 | 1.63 | 61.7 | 0.69 |
| (12) Indigenous values | 0.61 | 1.73 | 65.3 | 0.69 |
| (13) Fishing | 0.75 | 1.32 | 63.1 | 0.62 |
| (14) Mining and agricultural sectors | 0.51 | 1.77 | 63.1 | 0.57 |
| (15) Boating | 0.76 | 1.14 | 63.3 | 0.55 |
| (16) Commercial fishing sector | 0.46 | 1.76 | 61.6 | 0.50 |
| (17) Cheap shipping | 0.38 | 1.89 | 61.3 | 0.43 |
| (18) "Bragging rights" | 0.14 | 1.58 | 61.1 | 0.12 |
| (1) Environmental non-use values | | Average IDS score | | 1.55 |
| (2) Non-market use values | | Average IDS score | | 0.77 |
| (3) Indigenous culture | | IDS score | | 0.69 |
| (4) Industry use values | | Average IDS score | | 0.55 |
| (5) Recognition | | IDS score | | 0.12 |

**Table 4** Characteristics of respondents determining importance (I) and IDS scores for groups of values tested

| | Non-use (I, IDS) | Use (I, IDS) | Industry (I, IDS) | Indigenous (I, IDS) | Bragging (I, IDS) |
|---|---|---|---|---|---|
| Male | −, − | +, + | | −, − | −, − |
| Education | +, + | −, − | −, ° | | |
| Single | | | −, − | +, ° | +, + |
| Age | | | | −, − | −, − |
| Household income | | | +, ° | | −, − |
| Indigenous | | | | +, + | |
| Born in QLD | | | | −, − | |
| Household size | | | | | |
| Main household income from: | | | | | |
| Mining | | +, + | °, + | −, − | |
| Fishing | | +, ° | | +, ° | |
| Government | °, + | | | | −, ° |
| Tourism | | | | | +, ° |
| Agriculture | | | | | |
| Adjusted $R^2$ | .030, .026 | .043, .042 | .027, .021 | .086, .059 | .043, .028 |

*Mining* mining, manufacturing and ports, *Fishing* commercial fishing, *Government* government services including education, health etc., *Tourism* accommodations, cafes and restaurants; retail and tourism, *Agriculture* agriculture and forestry main income source

A plus-sign indicates that the variable was found to have a positive, and statistically significant relationship with the score assigned to the corresponding value; a negative sign indicates the relationship was negative and statistically significant; a blank or ° indicates no statistically significant relationship

All five values identified by residents as the most important (Fig. 2; Table 3) fell into the first category of environmental non-use values.

### IDS Action list

IDS scores are presented in Table 3. Being a compound index, items which appear at the top of the table do so because (a) respondents consider them to be important to their overall wellbeing and (b) respondents are dissatisfied with the current state of that item.

Management of visible rubbish emerged at the top of the Action List with an IDS score of 1.84. The next item was the preservation of the GBRWHA either for its own sake or for future generations (ranked second with an IDS score of 1.72), followed by the protection of iconic marine species such as whales, dugongs, and turtles (ranked third with an IDS score of 1.65).

When the IDS was calculated for groups of values (from the PCA), Environmental non-use values emerged as the highest priority, with an average IDS score of 1.55. Non-market use values had second highest average (0.77), followed by Indigenous culture (0.69, Table 3).

### Role of respondent characteristics

Using SUR model, we examined relationships between individual values and the socio-demographic characteristics of the respondents. Then, we regressed each of our five factors created using PCA (for importance, and then again for IDS) against variables measuring the socio-demographic characteristics of the respondents using stepwise Ordinary Least Square (OLS). Results were robust, with both the SUR and the OLS models identifying a similar set of statistically significant determinants. OLS results are presented in Table 4, with SUR results for Importance and Satisfaction provided in Tables S2 and S3, respectively (Electronic Supplementary Material).

Gender emerged as a significant determinant of all scores except those in the Industry group. Males viewed Non-use, -Indigenous and Recognition (bragging) values as relatively less important compared to females, and also placed these items further down the 'priority list' (using IDS). In contrast, males considered Non-market use values (e.g., fishing and boating) to be relatively more important to their overall quality of life than females, and placed these items higher on the 'priority list'.

Education also came through as a significant determinant of several responses. More educated people found Non-use values more, and Non-market use values and Industry relatively less important compared to other respondents. Single people also found Industry relatively less important, but Indigenous values and Recognition more important compared to those with families. People on higher household (HH) incomes felt that 'Industry' was more important to their overall wellbeing/quality of life than those on lower incomes. Unsurprisingly, Indigenous respondents thought that Indigenous values were more important than non-Indigenous respondents; but those born in Queensland thought that Indigenous values were less important than those born elsewhere.

Respondents whose household income was largely depending upon mining or manufacturing found Non-market use values more important, and Indigenous values less important compared to those respondents dependent upon other sectors for their incomes/livelihoods. They also considered Industry to be a higher priority than did others.

Explanatory powers of the models were generally low, with the 8.6 % explanatory variance for importance of Indigenous values the highest (Adjusted $R^2$ in Table 4).

## DISCUSSION

### Resident preferences and priorities

In this study we assessed the importance of values related to the GBRWHA from the point of view of local residents, and found that environmental non-use values of the GBRWHA are very important to their wellbeing (Fig. 3). The characteristics of residents' immediate surroundings have been previously found to have an important role in explaining their sense of wellbeing (Brereton et al. 2008). Having beaches and islands without visible rubbish was reported as the most important value, followed by maintenance of healthy reef fish and healthy coral reefs. Both use and non-use values related to the natural environment were reported as more important than the commercial activities ('Industries'), such as mining, agriculture and commercial fishing. Indeed, the literature suggests that stronger attachments tend to develop with attractive landscapes (Kaltenborn 1998), supporting our findings that high importance to environmental aspects was assigned by those living in the GBRWHA.

Non-use values also emerged at the top of the Action List for management, derived using IDS methodology. Interestingly, the separability of the various non-use values explored in this study was very low, with eight falling into the same group when using PCA.

### Divergent preferences among stakeholder groups

We found that educated females, and those who are dependent upon the government for income, assign more importance to, and are less satisfied with the current


**Fig. 3** Environmental non-use values such as healthy coral reefs and reef fish (**a**), iconic species (**b**), and clear ocean (**c**) were the most important contributors, out of those tested, to the wellbeing of the 1546 responding residents of the GRBWHA. Educated females, and those employed in government, assigned more importance and were less satisfied with the current condition of the non-use values than other respondents. Males, those without a university degree, and those employed in the mining and fishing industries placed more importance on non-monetary use values (such as fishing and boating, (**d**)) than other respondents. Photo © Matt Curnock

condition of non-use values, then their less educated, male and/or non-government counterparts. These findings are in accordance with the previous studies which found that well-educated people (Van Liere and Dunlap 1980; Jones and Dunlap 1992; Dietz et al. 1998) and women (McStay and Dunlap 1983; Blocker and Eckberg 1997; Bord and O'Connor 1997) tend to be more concerned about environmental problems than their counterparts are. On the other hand, less educated males, dependent upon the mining or fishing industries placed more importance on non-monetary use-values than their more educated, female and/or non-mining, non-fishing dependent counterparts (Fig. 3).

People with families, higher household income and lesser education found the Industry group of values to be more important than their single, poorer, better educated counterparts. Previous studies have hypothesized that those with higher incomes should be more concerned about environmental problems. Several explanations have been put forward, from those based on Maslow's hierarchy of needs (that those who have satisfied their basic material needs become more concerned about higher level needs such as better environmental quality), to those suggesting that high-income people are more likely to have post-materialist views emphasizing quality of life and environmental sustainability instead of economic growth (Van Liere and Dunlap 1980). However, as with the recent work of Liu et al. (2014), we found no evidence of higher importance of environment to those on higher incomes. Rather, people with higher incomes placed more importance on Industries.

Having different segments of population hold different perception about GBRWHA's contributions to their well-being has potential implications for management. Studies such as this assist in understanding how to navigate complex natural resource management and decisions, among different and sometimes competing values, and are pertinent to development of better informed awareness, education and engagement campaigns for the public.

Our findings also have implications for the future management of the GBRWHA, in particular, if the

demographic mix of the population changes. Currently, the fastest growing demographic group in the region is of young lesser educated males working in the mining and associated industries receiving relatively high incomes (Deloitte Access Economics 2013). Should this segment of population continue increasing, we may find that the importance of 'use values' (both those associated with the market and those associated with industry), rises *relative* to the importance of environmental non-use values. This might potentially make it more difficult in the future for conservationists or others to find support for policies that protect the GBRWHA at the expense of other things.

### Methodological implications

Recently, a lot has been written about a need for approaches that could be employed to incorporate non-monetary values of nature into societal decision-making processes (Norgaard 2010; TEEB 2010; Polishchuk and Rauschmayer 2012), as non-monetary values remain neglected in the public debate (Sagoff 1998). Satz et al. (2013) argue that scientists must therefore be careful not to exclude considerations that really matter to people from having a role in assessments and deliberations, in particular in the area of environmental assessment where focus has often been on easily measurable biophysical or economic metrics. Our research strongly supports their argument as the considerations that matter to the people of the GBR region are clearly of non-monetary nature. Human wellbeing and IDS approaches thus provide a valuable alternative to more traditional dollar-denominated methods.

While in our study and others, environmental non-use values were found to be of top priority, there is evidence that this is not always the case. Several holistic studies (looking at a range of aspects important to people's lives overall) found relationship with family; health and financial aspects to be more important than the environment (Bowling 1995; Larson 2010b). Holistic approaches to human values and wellbeing are therefore important in order to gauge the relative position (rank) of one value or a domain compared to others.

Finally we note that having quantitative data about the way in which individual values contribute to wellbeing, will facilitate the development of integrated modeling approaches (ones which incorporate ecosystem dynamics, human wellbeing and values, and also the impacts of human activities and climate change, mitigating procedures, management tools and regulations). Such integrated models have been proposed for improved management of a range of unique and large ecosystems, such as the Patagonian Fiords (Iriarte et al. 2010), the North American Great Lakes (Roy et al. 2010), the Baltic Sea (Österblom et al. 2013) and the northern Australian Tropical Rivers (Pantus et al. 2011). These models would also be valuable in the GBRWHA.

### Broader management implications

The rapid industrial growth along the GBR coast, and the resulting anthropogenic changes and risks, have prompted the UNESCO World Heritage Committee to express concerns for the future of the GBRWHA and to consider, potentially, placing it on the 'List of World Heritage in Danger' (UNESCO 2013). With only 1.17 % of the marine area of the world under some form of protection (Toropova et al. 2010) and the coral reefs worldwide suffering massive declines due to anthropogenic activities (Wilkinson 2004), it is dismaying to see that even protected reefs located in developed countries are facing increasing anthropogenic pressures resulting in reef degradation (Brodie et al. 2012), chronic large-scale eutrophication (Bell et al. 2014) and precipitous declines in coral cover (De'ath et al. 2012).

Results presented in this paper clearly indicate that environmental non-use values are of highest importance to local residents and are of highest management priority. Management of natural resources in Australia occurs at various institutional levels. For example, visible rubbish is managed by the Local Government Areas (City or Shire Councils). Land and coastal aspects such as the clarity of the water or healthy mangroves are the responsibility of the State government, while issues related to the oceans and the WHA itself are managed by the Federal government. Hence, although the top seven values most pertinent for management interventions found in this paper all collapse into a single 'non-use' group of values, responsibility for their management spans across local, regional, state and federal bodies.

Bohensky et al. (2011) argued that threats to the GBRWHA need to be managed through a multiple-scale, cross-agency and cross-community approach, and our finding (that respondents view these values as being related) supports that. Currently, numerous agencies share the responsibility for managing the GBR and catchments (Larson and Stone-Jovicich 2011), but there is no unified institutional management arrangement for the region. Historic management arrangements have resulted in mismatches between governance and ecosystem processes, exemplified by management that has been largely sectoral, narrowly-focused and short-term (Ferrier 2007). The establishment of a multiple-use spatial management (Day 2008), rezoning of the GBRWHA areas (McCook et al. 2010; Day and Dobbs 2013), introduction of the Reef Rescue Program (by Australian Federal Government) and the Reef Protection Package (by Queensland State Government) are examples of management actions being taken. Whether such actions are sufficient for achieving targets set

in the Reef Plan and whether this is the most appropriate form of management remains uncertain (Dale et al. 2013). This uncertainty needs to be constantly reviewed and re-assessed in light of an ever improving knowledge of Reef health, argue Dale et al. (2013), but we suggest that such assessments also include social, economic and cultural aspects of importance to residents of the GBRWHA.

## CONCLUSIONS

We found that absence of visible rubbish; healthy reef fish, coral cover and mangroves; and iconic marine species, were the most important contributors, out of those tested, to the wellbeing of the 1546 responding residents of the GRBWHA. Respondents were most dissatisfied with the commercial aspects of the GBRWHA, including benefits from the jobs and incomes related to mining, agriculture and commercial fishing sectors; as well as with levels of protection of Indigenous cultural values and preservation of the GBRWHA for its own sake and for future generations. Similar to other studies, responses were influenced by gender, educational levels, Indigenous status and sectors of employment.

Seven of the environmental non-use values emerged at the top of the Action List for management derived using IDS methodology, and all collapsed into the same 'value group'. But it matters not whether one considers individual values or value-groups: environmental non-use values associated with the GBRWHA are of highest importance to local residents and are the top management priority. Evidently, the 'outstanding universal value' of the GBR is well recognized by its residents, and the values associated with it are important contributors to their wellbeing and quality of life.

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