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Research article

Drivers of willingness to pay among scuba divers in the Great Barrier Reef

Alessia Costa [a,b,*], Matthew Curnock [c], Reniel B. Cabral [a,b,*]

[a] College of Science and Engineering, James Cook University, Townsville, QLD, Australia
[b] Centre for Sustainable Tropical Fisheries and Aquaculture, James Cook University, Townsville, QLD, Australia
[c] CSIRO Environment, Townsville, QLD, Australia

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ABSTRACT

Marine reserves are effective tools for protecting marine resources and ecosystems. However, financing their establishment and maintenance remains a challenge for many locales. Tourists and scuba divers are known to place a premium on pristine ecological conditions typically found inside marine reserves, which can be monetized in some cases by introducing a user fee. Here, we conducted a willingness-to-pay (WTP) study with a survey of 170 scuba divers who visited the Great Barrier Reef. We tested scuba divers' WTP for differing ecological conditions, as well as the protection status of dive sites. Using the contingent valuation method for five key ecological attributes of a hypothetical dive site - coral cover, coral diversity, fish diversity, fish abundance, and fish size - we found that divers' WTP was highest when all five attributes were present at high levels. Divers also placed a premium on the marine reserve's protection status and were willing to pay A$14.5 to dive in a marine reserve even if its conditions were identical to those in a fished zone. Finally, we found that 85 % of divers were willing to pay a user fee if the purpose of the fee (e.g., protection and management) was explicitly stated. Our results suggest that revenue can be generated from upgrading the protection status of dive sites, which can be used to support their restoration and maintenance.

1. Introduction

Marine reserves, or no-take marine protected areas, are an important management tool used to conserve marine ecosystems while supporting sustainable fisheries, tourism, and recreation (Cabral et al., 2025; Edgar et al., 2014; Lester et al., 2009; Sala et al., 2021). However, many marine reserves are underfunded, constraining their effective management and conservation efforts (BlueSeeds, 2020; Watson et al., 2014). Marine reserves that have successfully generated sufficient funds for their maintenance (e.g., compliance monitoring and enforcement), have done so by developing inter-institutional partnerships, engaging with the private sector, and/or increasing tourism-based revenue by collecting user fees (Bohorquez et al., 2023). For example, the Bonaire National Marine Park, Netherlands Antilles, introduced user fees in 1992, becoming the first Marine Park in the Caribbean with a self-financing mechanism (Bohorquez et al., 2023; Dixon and Scura, 1993; Thur, 2010).

For many terrestrial and marine parks with user fees charged to visitors, the fee structures are usually informed by Willingness-to-Pay (WTP) studies. WTP is the amount the consumer (or tourist) is willing to pay based on their ability to pay and their perceived value of the product, service, or experience (Tietenberg and Lewis, 2020). WTP studies have informed the establishment of user fees in many places; for example, in Mombasa Marine National Park and Reserve in Kenya, which when implemented, resulted in an increase of the Park's revenue by 60 %, supporting local efforts to improve reef health (Ransom and Mangi, 2010). However, implementing user fees in the absence of adequate research can risk setting such fees at a suboptimal level. The introduction of user fees well below what tourists are willing to pay, as in the case of the Galapagos Islands (Benitez et al., 2001), or too high, as in the case of some sites in Japan and Costa Rica (Chase et al., 1998; Shoji et al., 2023), can result in insufficient revenue, or a reduction in visitation rates (e.g., Schwartz and Lin, 2006; Shoji et al., 2023). Achieving sustainable financing for the protection of nature reserves can be challenging and not always achievable solely through user fees. Major financing sources among developed countries are typically domestic government budgets from tax revenue, while many developing countries rely on international assistance or contributions from various sources (i.e., multilateral funds) (Emerton et al., 2006). Although many funding mechanisms are available for marine and terrestrial protection,

* Corresponding authors. College of Science and Engineering, James Cook University, Townsville, QLD, Australia.
E-mail addresses: alessia.costa@my.jcu.edu.au (A. Costa), reniel.cabral@jcu.edu.au (R.B. Cabral).

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sustainable financing remains an ongoing challenge for many reserves (O'Flynn et al., 2022). Successful strategies like user fees in tourism sites can enhance management capacity and engage tourists in activities such as scuba diving to support conservation initiatives.

Marine scuba diving tourism is a significant contributor to the "blue economy" of many nations. World Bank defines the blue economy as the "sustainable use of ocean resources for economic growth, improved livelihoods and jobs, and ocean ecosystem health" (World Bank, 2017). Like other sectors of this economy, scuba diving tourism relies on healthy marine ecosystems and the sustainable use of marine resources to enable growth and improved livelihoods that coexist with the natural marine environment. Marine and coastal tourism is projected to contribute over US$ 777 billion in value added to the global economy by 2030 (OECD, 2016), and scuba dive tourism is an important component of this sector in many islands and coastal nations (Northrop et al., 2022). Globally, marine scuba diving tourism is estimated to generate revenue of US$ 8.5 billion to US$ 20.4 billion annually (direct and indirect expenditures), with up to 13.6 million people undertaking diving activities annually (Schuhbauer et al., 2023) performing 33.1 million dives per year (Cabral et al., 2025). Understanding divers' aesthetic preferences for natural features of dive sites and locations provides valuable insights for a range of purposes, including spatial decision-making for marine protected areas, priorities for conservation and restoration, as well as estimating appropriate WTP to access sites of varying habitat types and ecological conditions that could inform potential access fees as a sustainable revenue source to support marine resource management.

WTP has been used to identify particular aesthetic features that are highly valued by divers, including the proportion of live coral cover, fish abundance, and underwater visibility (Guerra et al., 2018; Huth and Morgan, 2011; Polak and Shashar, 2013; Thur, 2010; Trujillo et al., 2016). Often, divers' WTP and environmental perceptions are influenced by their demography (e.g., age, gender), education, their level of prior experience and ecological knowledge, and environmental values (Baysan, 2001; Peters and Hawkins, 2009; Zunino et al., 2020). Environmental attributes indicative of a healthy ecosystem have been shown to attract higher diving demand. However, it has been suggested that the local conservation practices and protection status of a dive site can also influence diving demand (e.g., Cabral et al., 2025; Sala et al., 2013; Viana et al., 2017). In at least one study, divers were observed to be willing to pay more to visit sites with protection measures in place to enhance local biodiversity (Sorice et al., 2007). It has been noted that many scuba divers have a good perception of changes in key attributes that affect the enjoyment of the dive experience (Uyarra et al., 2009), and their purchasing/travel decisions are influenced by the perceived quality and/or uniqueness of the diving location (Dwyer and Kim, 2003).

1.1. Case study context: the Great Barrier Reef

Australia's Great Barrier Reef (GBR; the Reef) is the world's largest coral reef ecosystem. It is protected and managed by the Great Barrier Reef Marine Park Authority (Reef Authority), with complementary state and federal legislation that enables it to be managed for multiple human uses, including commercial and recreational extractive and non-extractive activities, including fisheries and tourism. Potential conflicts between such activities are managed, and ecological values are protected through a Marine Park Zoning Plan, which allows certain activities to be conducted in different spatial areas or zones (Great Barrier Reef Marine Park Authority, 2004). Among the different types of zones, Marine National Park (Green) Zones, representing approximately 33 % of the entire Marine Park, are 'no-take' and prohibit extractive activities such as fishing and collecting, while allowing recreational and tourism activities such as snorkeling and scuba diving. Studies on the ecological effects of these no-take zones have shown that such areas typically exhibit higher fish biomass, and are more resilient to natural disturbances (e.g., cyclones) than other zones subject to extractive activities (Hall et al., 2023).

While spatial management and zoning of the GBR have been shown to be effective in the management of local stressors, it is increasingly recognized that such management is insufficient for protecting the Reef's ecological values from rising ocean temperatures caused by human-induced climate change. Recurrent marine heatwaves in the last decade have led to mass coral bleaching and mortality at unprecedented scales, threatening to fundamentally alter ecosystem functions and services (Great Barrier Reef Marine Park Authority, 2019, 2024c; Hughes et al., 2017; Reimer et al., 2024). In recognizing this threat, GBR managers are exploring new approaches to building Reef resilience, which include direct interventions (e.g., coral restoration technologies), as well as efforts to improve compliance among Reef users with the Zoning Plan (Great Barrier Reef Marine Park Authority, 2024b). Zoning remains an important management tool, and while the Reef Authority has not indicated any planned changes to the current Zoning Plan, it is conceivable that re-zoning may be considered in the future in response to ecological changes and human pressures.

Tourism in the GBR has been estimated to generate A$5.7 billion annually for the Australian economy (O'Mahoney et al., 2017). Most visitors accessing the GBR Marine Park via commercial tour operators pay an access fee (the 'Environmental Management Charge, or EMC) that contributes to the operating budget of the Great Barrier Reef Marine Park Authority (Great Barrier Reef Marine Park Authority, 2023), and hence the operational management of the Marine Park. The EMC is collected by tour operators at a standard rate (A$8 per visitor for a full day or A$4 for a part day) that does not distinguish between different management zones (Great Barrier Reef Marine Park Authority, 2024a).

1.2. Study aims

In light of the GBR's precarious outlook (Great Barrier Reef Marine Park Authority, 2024c) and the potential future need for greater resourcing to protect and/or restore reefs, this study investigated scuba divers' WTP in the region. Our study in the GBR sought to (i) disentangle scuba divers' WTP for various changes in coral reef ecosystem conditions, (ii) quantify divers' WTP for the protection status of the dive site, and (iii) determine whether stating the purpose of the user fee increased divers' acceptance of the fee. Specifically, our study sought to determine the conditions (i.e., biological or protection status) that drive the demand for dive tourism and divers' perception of user fees to access the marine reserves of the GBR. The findings of this research are intended to assist coral reef managers in the GBR region and elsewhere, who may be considering future revenue sources to sustain the maintenance of marine protected areas, and potentially contribute to coral reef restoration efforts. Our study also contributes to a broader literature of WTP studies associated with marine protected areas and scuba divers' preferences.

2. Methods

2.1. Survey design, ethics, and respondent recruitment

The survey instrument was a questionnaire designed to gather both qualitative and quantitative data. Specifically, we used an economic non-market valuation method combined with a summative rating method. One of the most used non-market methods for the evaluation of tourism activities is the contingent valuation method (CVM) (e.g., Polak and Shashar, 2013; Ransom and Mangi, 2010; Trujillo et al., 2016), which was employed here. CVM was used to estimate the value that divers placed on five biological attributes (i.e., coral cover and diversity, fish diversity, size, and abundance) that vary in quality and the protection status of the dive site.

Here, we define scuba diving visitors of the GBR Marine Park as paying divers, local and/or non-locals, visiting the GBR Marine Park for various purposes, including tourists and local residents who dive for recreation. The term 'marine reserve' was used throughout the questionnaire instead of 'Marine National Park Zone' because not all surveyed respondents were expected to be familiar with the GBR Marine Park Zoning Plan. Ethics Approval (H8861) from the survey instrument was obtained from the James Cook University Human Research Ethics Committee in accordance with the *National Statement on Ethical Conduct in Human Research (2007) (updated 2018)* guidelines.

The survey instrument was pre-tested on seven divers from James Cook University Townsville and modified accordingly before being used for the main data collection. Each participant was asked to answer a total of 22 questions divided into three sections:

1. Demographic information (e.g., age, gender, country of residence),
2. Scuba diving experience (e.g., certification level, number of dives in the GBR),
3. WTP questions (related to both biological attributes and protection status).

Questions about divers' demographic information were included, such as gender, age, country of residence, and reason for being in Australia (e.g., vacation, work, backpacker, study, etc.) (see Supplementary Material for the questionnaire). We also collected diving-specific information and experience, such as certification level, date of last dive, and whether divers had dived in the GBR before (and how many dives). Finally, we asked divers how important each feature listed was for them when selecting a dive site on a Likert scale of 0–5 (where 0 was not important and 5 extremely important).

Divers were recruited using two strategies: online, through a social media platform (Facebook™ group pages), and through dive operators. A link to the online questionnaire was posted on Facebook™ diving-related groups (with admins and/or moderators' consent). Dive operators in Port Douglas, Cairns, Townsville, Ayr, and Whitsundays were identified using a Google™ search of websites, using the terms "diving tours" AND the location names above. With consent from the managers of scuba dive tour operators, scuba diving guests who participated in dive trips on a total of four dive operators were surveyed between June 2023 and November 2023. A total of 170 divers were surveyed: 92 through dive operators' recruitment (paper questionnaires) and 78 through QR codes (through either dive operators or social media recruitment).

2.2. Contingent valuation method (CVM) and Bias Reduction

CVM with payment card elicitation was used to evaluate divers' WTP. The questionnaire was designed to minimize biases associated with the CVM. Information bias, which occurs when participants evaluate goods they have little to no experience with (Ajzen et al., 1996), was minimized by targeting certified divers. Thus, divers' WTP was assumed to reflect the monetary value assigned to the different attributes proposed in the questionnaire scenarios. Hypothetical bias arises for hypothetical payments that differ from the actual payment due to the respondent incorrectly picturing the scenario. Few techniques are used in the literature to control for hypothetical bias (e.g., 'cheap talk', certainty statements; e.g., Cummings and Taylor, 1999; Huth and Morgan, 2011). However, these were not always found successful when respondents had more familiarity with the goods surveyed (e.g., List, 2001). Furthermore, a review conducted by Johnston et al. (2017) suggests that when assessing use values (e.g., diving activities in coral reefs) tied to real markets, the impact of hypothetical bias is minimal or negligible. Therefore, we did not control for hypothetical bias. Strategic bias is derived from understating or overstating WTP in order to affect policy (Venkatachalam, 2004) and cannot be controlled. However, the study was presented and described to respondents as being of a purely academic nature, to avoid any potential misunderstanding that it might be related to policy.

We used a payment card elicitation method where the divers are presented with a range of bids to choose from (Peters and Hawkins, 2009), with the option to make an open-ended bid in case the diver's WTP is higher than the available bid options. Other elicitation methods are available in the literature (e.g., open-ended and dichotomous choice); however, the payment card approach was found to be the most adequate in minimizing starting point bias (Mitchell and Carson, 1981). It reduces the anchoring of a single bid, decreasing non-response rates and eliminating 'the need for prompting by the interviewer' (Kirkbride-Smith et al., 2016). Based on this evidence, a payment card was selected as the elicitation method, with bids ranging from A$0 to A $30 in increments of A$5 or more than A$30 to be stated (Fig. 1). Questions focused on attributes inside marine reserves (equivalent to Marine National Park Zones for respondents not familiar with the GBR Marine Park Zoning Plan), with the answers used to evaluate Marine National Park Zones. WTP was selected over Willingness to Accept (WTA) due to the reoccurring issue of overstating WTA caused by respondents' perception that private goods are not suitable substitutes for the public goods considered in the surveys (Hanemann, 1991).

2.3. Experimental design - Biological attributes and levels

Twelve (12) WTP questions were used to discern divers' WTP to biological attributes (10 questions) and the protection status of dive sites (2 questions). Attributes (or features) and levels were selected from a review of relevant literature, including specific attributes deemed important for the quality of the dive experience (e.g., Emang et al., 2016, 2017, 2020; Kragt et al., 2009; Malpica-Cruz et al., 2017; Polak and Shashar, 2013; Shideler and Pierce, 2016), or that were 'signature' experiences for the GBR Marine Park (e.g., big fishes, coral diversity, abundant coral cover). Six attributes were then selected, focusing on biological conditions and protection status: (1) coral cover, (2) coral diversity, (3) fish diversity, (4) fish abundance, (5) fish size, and (6) dive site protection status. Each biological attribute consisted of three associated levels. Attributes and levels were based on the level breakdown of an established protocol in long-term monitoring programs (e.g., Australian Institute of Marine Science (AIMS) long-term monitoring program for coral cover) and previous studies that used a similar approach (e.g., Grafeld et al., 2016; Shideler and Pierce, 2016). Attributes and levels were:

1 Coral cover: The AIMS Long-term Monitoring Program in the GBR considers five live coral cover level categorization: (1) 0–10 %, (2) 10–30 %, (3) 30–50 %, (4) 50–75 % and (5) 75–100 %. We estimated that low, medium and high coral cover levels would fall approximately and respectively at 0–30 %, 30–70 %, and >70 % coral cover (Australian Institute of Marine Science, 2021).
2 Coral diversity: Diversity was expressed in morphologies (or shapes, simplified in the questionnaire) and, for consistency with fish diversity levels, levels were set at 1–3, 4–7, and 8–15 morphologies corresponding to low, medium, and high coral diversity levels.
3 Fish diversity: Levels were based on fish diversity levels used by Grafeld et al. (2016). Low, medium, and high levels correspond to 1–3 species, 4–7 species, and 8–15 species, respectively.
4 Fish abundance: Abundance was used instead of biomass and expressed as the number of fishes in the questionnaire. Low, medium, and high fish abundance was based on Shideler and Pierce (2016) and set to 0–15, 16–30, and 31+ fishes.
5 Fish size: Small, medium, and large fish sizes were set at <10 cm, >10–25 cm, and 25+ cm.
6 Protection status: Fishing restrictions (both recreational and commercial) in dive sites.

Two WTP questions in the survey were included to assess the WTP of divers to the protection status of dive sites. In two scenarios, the five biological conditions were kept at medium level (baseline), and the protection status was changed from a fished zone to a marine reserve and from a marine reserve in the Philippines to a marine reserve in the

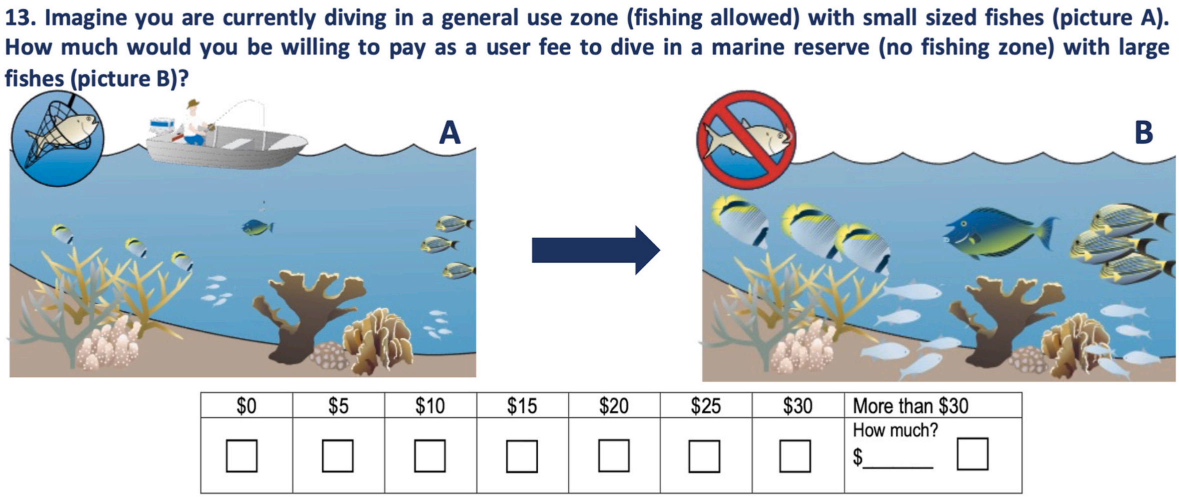

Fig. 1. An example from the questionnaire handed to divers to assess their willingness to pay when comparing different fish sizes in fishing (general use zones) and non-fishing areas (marine reserve).

GBR. Finally, respondents were asked whether they would pay a user fee knowing that the collected fee would be used in managing the GBR.

2.4. Statistical design and data analysis

During data cleaning, vague and unreliable responses were excluded from the final dataset. Respondents who are residents of Australia and are not Australian citizens were classified as 'non-local', while Australian citizens were classified as 'local'. For respondents eliciting WTP such as "$50+" with no additional comment, elicited WTP was considered as $50. If the respondent selected the option "More than $30, How much?" in the WTP questions without stating a price, we used the mean WTP of all the other WTP responses whose numerical value is greater than $30. The same approach was used for answers that elicited their WTP higher than $30 and added comments on diving minutes (e.g., "Depends on the max time. $45 or up if I can dive at least 70 min"). Average WTP was calculated for each of the five biological attributes and for the protection status to understand what the WTP of GBR Marine Park visitors is to dive exclusively in a marine reserve if better underwater sightings were guaranteed.

We used a second approach to quantify divers' dive site choices. We asked divers to rank proposed biological, social, and protection features (e.g., protection status, shark sightings, live coral cover, site crowding, etc.) on a 5-point Likert scale (where 0 = not important and 5 = extremely important). We compared this to the WTP we generated from the first approach, assessing whether divers assign the same weight to the same features through different scales.

Data was analyzed using R (R Core Team, 2025; ver. 4.2.3). A Generalised Linear Mixed Model was initially used to test the association between divers' demographic information, diving experience, and country of provenance. Questionnaire type (i.e., paper or online questionnaires) and Survey ID were set as the random variable and each WTP question was considered as a singular entry. Model validation was conducted with R package "DHARMa" (Residual Diagnostics for Hierarchical (Multi-Level/Mixed) Regression Models) (Harting, 2024), and we found that the model variance was overdispersed and zero-inflated. To deal with overdispersion and zero inflation, we selected a Hurdle Poisson regression with random effects. The Hurdle Poisson is a truncated model that helps with overdispersion and zero-inflation by splitting zeros and positive values and dealing with them separately. Furthermore, some extreme WTP values were observed (e.g., $150). However, after further investigation, we did not treat them as outliers. No data transformation was done on the response variable as this would have further complicated its interpretation (i.e., Poisson distribution uses a log-link; e.g., O'Hara and Kotze, 2010). We used a ternary system to indicate the change in level from picture A to picture B for each attribute:

- no change in level (i.e., medium in pictures A and B) was coded with 0;
- change in 1 level (i.e., from low in picture A to medium in picture B) was coded with 1;
- change in 2 levels (i.e., from low in picture A to high in picture B) was coded with 2.

For questions that changed one attribute at a time, all other conditions were kept at moderate/medium level and coded as 0. The presence of the marine reserve was coded with 1. The coding system assumes moderate/medium biological conditions and the absence of marine reserves as a baseline level. Using a ternary coding system assumes that the change in WTP when a specific biological attribute changes its condition from low to medium and from medium to high is equal and linear.

The regression model used in the analysis of respondents' WTP is as follows:

$$\begin{aligned}\ln\mathrm{WTP}(x_i) = {} & \beta_0 + \beta_1 \textit{ageclass}_i + \beta_2 \textit{gender}_i + \beta_3 \textit{certificationlevel}_i \\ & + \beta_4 \textit{visitortype}_i + \beta_5 \textit{coralcover}_i + \beta_6 \textit{coraldiversity}_i \\ & + \beta_7 \textit{fishdiversity}_i + \beta_8 \textit{fishsize}_i + \beta_9 \textit{fishabundance}_i + \varepsilon_i + u_i\end{aligned}$$

Where the β are the fixed effects, ε and u are the intercepts to estimate the variance between 'questionnaire type'(ε) and between 'survey ID' (u) (i.e., random effects), and the index i indicates the individual sample. The questionnaire type and the survey ID were set as the random effects to account for variation among responses received through paper and online questionnaires and variation among different respondents (i.e., survey ID).

3. Results

Over half of the respondents (divers hereafter) were aged between 18 and 29 (52.35 %), 18.24 % aged between 30 and 39, 9.41 % aged between 40 and 50, and 20 % aged over 50 (Table 1). 59.41 % of the divers were female, 38.24 % were male, and 1.18 % were non-binary. 49.41 % of the divers were visa holders (non-locals), and 48.82 % were Australian citizens (locals). Divers were divided into three certification levels: Open/Advanced, Rescue Diver, and Higher certifications. The majority (54.17 %) of respondents held an Open or Advanced certification, followed by Higher certifications with 26.47 %, and Rescue Divers with 18.82 % (Supplementary Material Table S1). Most (81.18 %) of the

Table 1
Demographic profile of diver respondents (number of respondents n = 170).

Characteristics		Respondents	
		n	%
Gender	Female	101	59.41
	Male	65	38.24
	Non-binary	2	1.18
Age	18–29	89	52.35
	30–39	31	18.24
	40–50	16	9.41
	50+	34	20
Residence	Australian citizen	83	48.82
	Visa holders	84	49.41

divers had previously dived in the Great Barrier Reef (GBR), with 64.49 % logged more than ten dives and 34.78 % logged ten or fewer dives.

When divers ranked the factors influencing their dive site selection, with five (5) being extremely important and 0 not important, divers selected water visibility as the most important factor, with a mean rank value of 3.92 ± 0.09 (standard error or SE), followed by high fish abundance (3.84 ± 0.08), and high fish diversity (3.81 ± 0.09; Table 2). Divers assigned the lowest rank values to protection status and absence of fishing activities, with mean rank values of 3.25 ± 0.11 and 3.23 ± 0.12, respectively.

Divers were asked to select their preference between two biological features or assign equal weight or preference to both features (Fig. 2). When asked if divers preferred fishes or corals, 52.94 % assigned 'equal weight', 31.76 % preferred fishes over corals, and 14.12 % preferred corals over fishes. When asked if divers prefer to see many small fishes versus one big fish, 42.94 % assigned 'equal weight', 38.82 % preferred high fish quantity, and 17.65 % preferred to see a big fish. When the options are between coral cover and coral diversity, 38.23 % of divers assigned 'equal weight', 37.06 % preferred coral diversity over coral cover, and 23.53 % preferred coral cover over coral diversity (Fig. 2, Supplementary Material Table S2).

The Hurdle Poisson regression model produced two outputs: a conditional model (Table 3) and a zero-inflation model (Supplementary Material Table S3). In the conditional model, coral cover, fish diversity, and fish abundance mainly drive changes in the WTP. For a unit increase in coral cover and fish diversity, WTP will increase respectively by 7.65 % and 6.87 %. For a unit increase in fish abundance and fish size, divers' WTP increases by 4.65 % and 5.79 %. Out of the five biological attributes used in the questionnaire, coral diversity drives the smallest change in WTP at 1.53 % increase in WTP per one unit increase in coral diversity. Although differences in WTP between the demographic profiles were not statistically significant, these profiles were retained in the model to account for potential effects of demographics on WTP. For demographic profiles, males drive higher WTP, respectively, by 10.28 % compared to females. Locals (Australian citizens) have a higher WTP compared to visa-holders, by 21.79 %.

Table 2
Dive site selection attributes ranked by diver respondents (number of respondents n = 170, mean rank ± standard error or SE).

Dive site attribute	Mean importance (on a 0–5 scale)	±SE
Water visibility	3.92	0.09
High fish abundance	3.84	0.08
High fish diversity	3.81	0.09
High live coral cover	3.77	0.08
Uncrowded dive site	3.64	0.10
Diverse corals	3.63	0.09
Presence of big fishes	3.46	0.09
Turtle sightings[a]	3.37	0.10
Shark sightings	3.33	0.10
Protection status	3.25	0.11
Absence of fishing activities	3.23	0.12

[a] Mean importance value for turtle sightings was calculated based on n = 92 as this specific feature was present only on the paper questionnaire.

We use divers' answers to show the probability distribution of divers stating WTP for high levels of corals and/or fishes attributes inside marine reserve (compared to low levels in fished areas) when these were individually presented or combined. Divers were presented with five questions with high levels of biological conditions and one question with biological conditions at baseline level (Fig. 3a). The highest mean WTP was estimated for coral cover (A$22.83 ± 1.40), while the lowest was coral diversity (A$19.62 ± 1.14). When the unprotected area was compared to the marine reserve, mean WTP was estimated at A$14.53 (±1.37), with distribution skewed towards lower WTP values (Fig. 3a). For coral cover, coral diversity, fish diversity, and fish size, there is a high probability for WTP to be stated under A$20, while fish abundance has the highest probability to be stated over A$25. The shape of the distribution plot shows that the divers' WTP for the five biological attributes are mostly concentrated around the median, and there are lower probabilities that divers state higher WTP values. Respondents were also asked how much they would be willing to pay to dive inside a marine reserve at varying combinations of the five biological attributes, with all combined attributes changing from low to high levels. WTP responses are concentrated around the median (Fig. 3b). There is a low probability for divers to state WTP values over A$40; the maximum WTP value stated is A$150 for scenarios when fish attributes are combined and when coral and fish attributes are combined, while the maximum WTP stated for coral attributes combined is A$90 (Fig. 3b).

We estimate the mean WTP stated by divers for varying levels of the five biological attributes and ranked from the highest to the lowest (Table 4). The highest WTP was assigned to the scenario where coral and fish attributes are combined and are at high levels inside marine reserve (A$28.11 ± 1.79). This is followed by the scenario with all fish attributes combined and at high levels (A$25.89 ± 1.72), and when there is a high coral cover (A$22.83 ± 1.40), all inside marine reserve. The lowest mean WTP was estimated when respondents were asked about diving in a marine reserve in the GBR Marine Park rather than a marine reserve in the Philippines (A$14.26 ± 1.21), and the scenario comparing a marine reserve to a fished area (A$14.53 ± 1.37), in which all five biological conditions are at the baseline level. Interestingly, coral diversity was the lowest-ranked biological condition when it was present at high levels inside marine reserve, with a mean WTP of A$19.62 ± 1.14.

Divers were asked whether they would be willing to pay a user fee, knowing that 100 % of the revenue would be used to manage the GBR. 84.71 % (n = 144) of the divers responded 'yes', 12.35 % (n = 21) responded 'no', and 2.94 % (n = 5) did not answer the question.

4. Discussion

We explored the scuba diving sector of the Great Barrier Reef (GBR) to understand how divers' WTP is shaped by coral reef ecosystem health and protection status and whether the introduction of a user fee to dive in marine reserves would be perceived positively or negatively. We found that divers were willing to pay A$14.5 to dive in marine reserves regardless of their ecological conditions; however, as ecological conditions improved in marine reserves, their WTP increased. The ecological attributes most preferred by divers were coral cover and fish abundance. Finally, we found that a high proportion (85 %) of respondents would be willing to pay a user fee if the user fee's purpose was explicitly stated. These findings suggest there is a potential opportunity to generate additional funding from GBR scuba divers, visiting sites with no-take protection status and with favorable ecological conditions to support the Reef management.

4.1. Diving experience and Biological preferences

Sampled divers were mostly represented by women and age class 18–29. The majority of divers had previously dived over 10 times in the GBR and many were experienced reef divers. The demographic that took

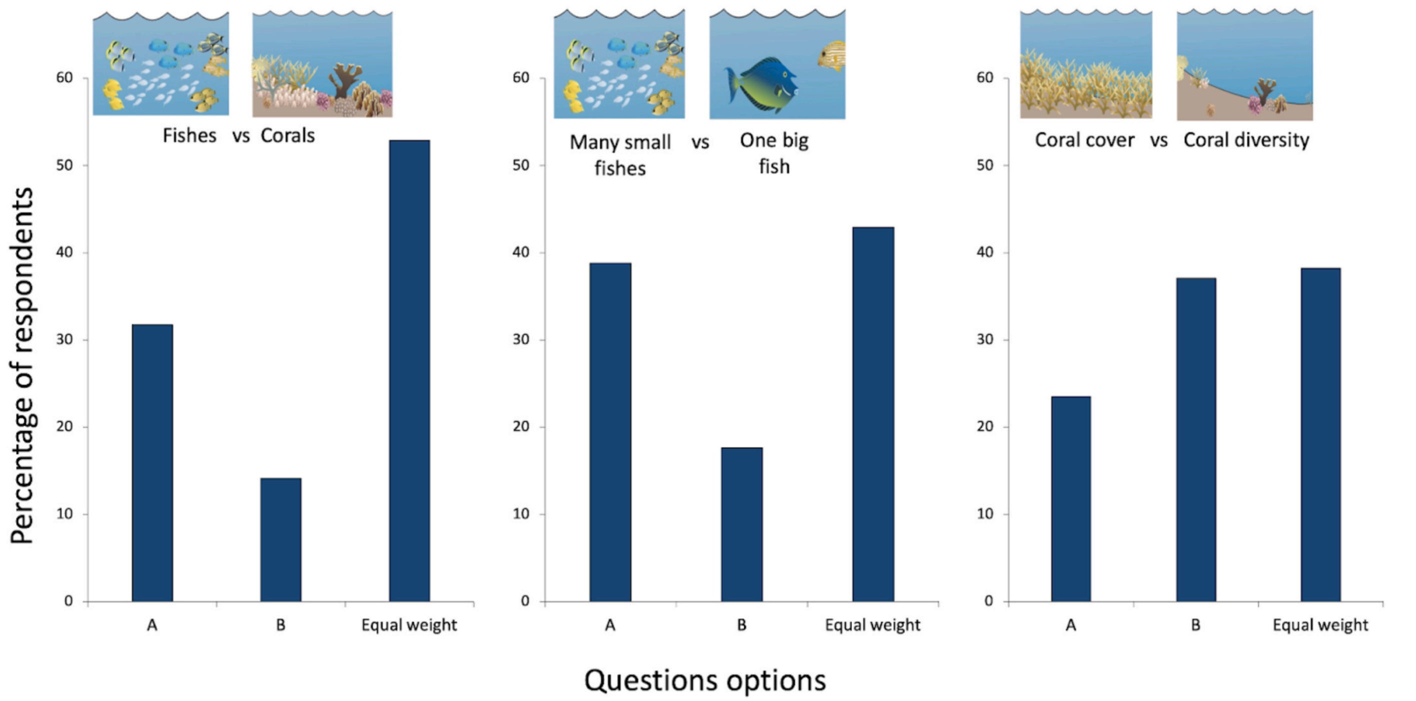

Fig. 2. Survey results showing divers' preferred diving attribute (A, B, or equal weight) for three scenarios: fish or corals, many small fishes or one big fish, coral cover, or coral diversity.

Table 3
Hurdle Poisson regression results disentangling drivers of willingness to pay. Drivers considered are the biological attributes of dive sites, divers' demographic information, and diving experience. 'Questionnaire type' was set as the random variable. n = 1759, df = 1733, and estimated coefficients are on a ln scale.

	Estimate	Standard Error	% change	Lower and upper bound % change	p-value
Intercept	2.631	±0.09			<2e-16***
Coral cover	0.074	±0.006	7.65 %	7.03–8.33 %	<2e-16***
Coral diversity	0.015	±0.006	1.53 %	0.90–2.12 %	0.026*
Fish diversity	0.066	±0.007	6.87 %	6.08–7.57 %	<2e-16***
Fish abundance	0.045	±0.007	4.65 %	3.87–5.34 %	3.69e-10***
Fish size	0.056	±0.007	5.79 %	5.02–6.50 %	2.88e-14***
Age class	0.041	±0.047	4.27 %	−0.59–9.19 %	0.378
Gender[a]					
Male	0.097	±0.1	10.28 %	−0.29–199.7 %	0.331
Non-binary	0.621	±0.564	86.14 %	5.67–205.87 %	0.271
Visitor type[b]					
Locals	0.197	±0.103	21.79 %	9.86–209.86 %	0.056
Diving license[c]					
Higher	0.008	±0.12	0.83 %	−10.59–189.40 %	0.945
Rescue	−0.075	±0.125	−7.26 %	−4.88–195.12 %	0.545
$\sigma^2_{\text{questionnaire type}}$	2.842e-09	±5.331e-05[d]			
$\sigma^2_{\text{survey ID}}$	3.058e-01	±5.53e-01[d]			

*p < 0.05.
**p < 0.01.
***p < 0.001.
[a] Reference category is 'female'.
[b] Reference category is 'non-locals'.
[c] Reference category is 'Open/Advanced level'.
[d] Variance ± Standard Deviation.

part in the survey is consistent with a global survey indicating an increase in female divers and most divers in age class 18–29 (PADI, 2021). Most respondents held lower certification levels (Open or Advanced), with a smaller proportion holding higher certification levels (e.g., Rescue or Divemaster), which is expected to be commensurate with diving experience. Several studies have shown that diving experience is a key factor in dive site selection and value attribution for biological conditions. More experienced divers tend to prefer more biologically rich dive sites (Zhang et al., 2022). Studies have also shown that less experienced divers express greater interest in megafauna sightings (e.g., sharks and turtles), while more experienced divers express greater interest in rare and cryptic species (Giglio et al., 2015).

The key attributes driving the demand for diving in the GBR in our GBR study were high coral cover and high fish abundance, followed by high fish diversity. In Guam, it has been found that divers prefer sites with healthier reefs, such as high fish biomass and diversity (Grafeld et al., 2016). In Barbados, Schuhmann et al. (2013) found that divers had a strong appreciation for good coral cover and fish diversity, and the price that they would be willing to pay to dive in such conditions was significantly higher than what they were currently paying. In our study,

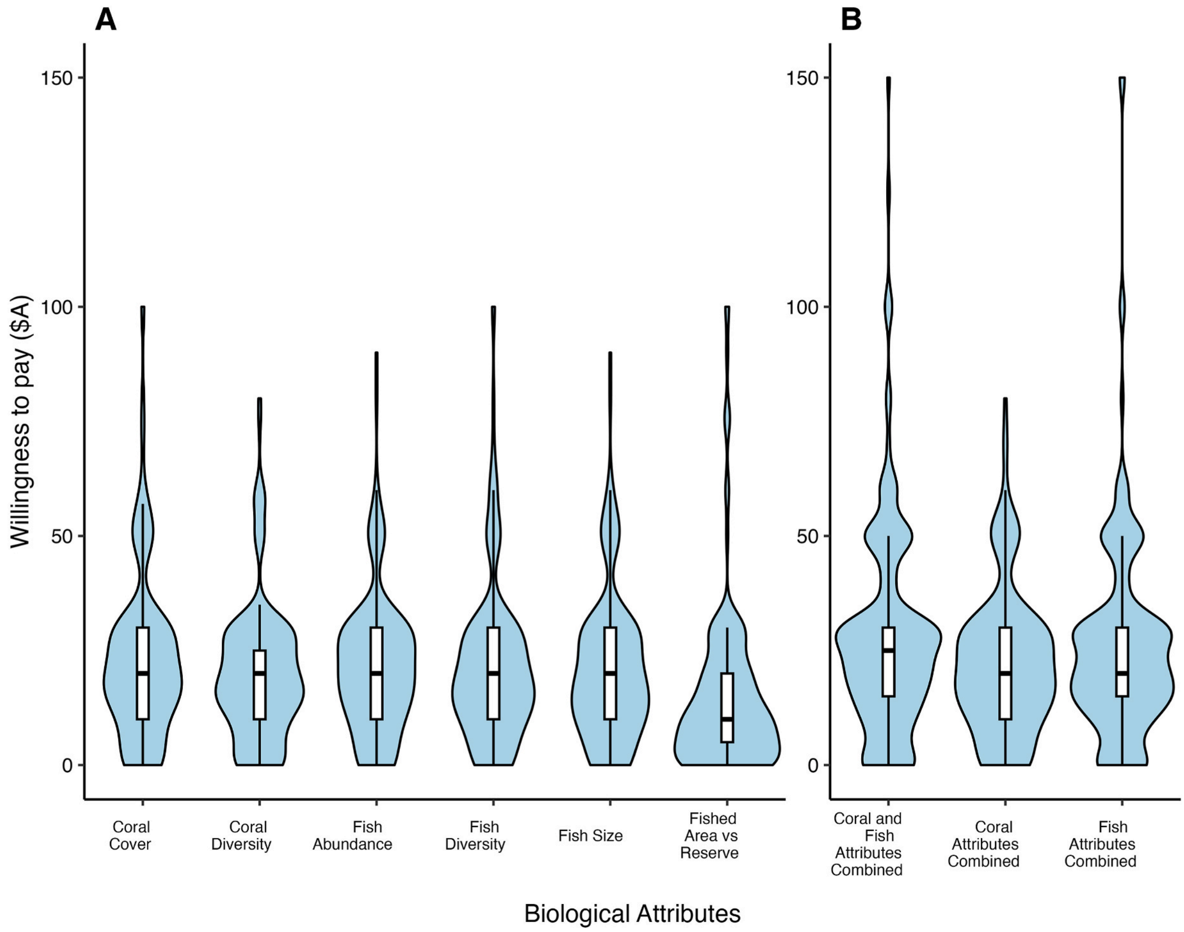

Fig. 3. Distribution of willingness to pay (WTP) responses for individual attributes (A) and combined attributes (B). WTP was stated by divers (A) for the five biological conditions (coral cover, coral diversity, fish abundance, fish diversity, fish size) when these were presented to divers at high levels in marine reserve and when comparing a fished areas and marine reserve with the same biological conditions at baseline level (i.e., compares a fishing zone to a marine reserve with the same moderate biological conditions). Divers' WTP for three scenarios where coral and/or fish attributes are combined (B): coral and fish attributes combined, coral attributes (cover and diversity) combined, and fish attributes (size, diversity, and abundance). Where the violin shape is wider, it indicates higher probabilities of that WTP value (A$) to be stated by divers. The black horizontal line inside the box plot is the median value, the box is the interquartile range, while the vertical lines represent the rest of the distribution, excluding outliers.

Table 4
Mean willingness to pay WTP (± standard error SE) for the 12 scenarios presented in the questionnaire ranked from the highest to the lowest.

Biological Levels	Attribute	Mean WTP (A $)	Relative WTP increase to marine vs fished area (14.53 A$)	±SE
Low to High	All coral and fish attributes	28.11	+13.58	1.79
Low to High	All fish attributes	25.89	+11.36	1.72
Low to High	Coral cover	22.83	+8.30	1.40
Low to High	All coral attributes	21.89	+7.36	1.20
Low to High	Fish abundance	21.29	+6.76	1.17
Low to High	Fish diversity	21.17	+6.64	1.35
Low to High	Fish size	20.55	+6.02	1.24
Low to High	Coral diversity	19.62	+5.09	1.14
Low to Medium	Fish abundance	16.81	+2.28	1.01
Low to Medium	Coral cover	16.48	+1.95	1.11
Medium	Marine reserve vs fished area	14.53	0	1.37
Medium	GBR vs Philippine marine reserves	14.26	−0.27	1.21

we found fish abundance to have a greater effect on mean WTP than fish diversity, which contrasts with findings from Polak and Shashar (2013) in the Gulf of Eilat, Israel, who found fish abundance to be the least favored attribute. However, in that study corals also scored a higher WTP value than fish (Polak and Shashar, 2013), which is consistent with our results. In other locations, like Jamaica, fish-related attributes (e.g., diversity, size, abundance, and unusual species) are more valued than benthos-related attributes (e.g., coral diversity, size, and cover, sponges, lobsters, and crabs) (Williams and Polunin, 2000).

While it is widely accepted that scuba diving tourists appreciate natural and healthy marine habitats (Curtin, 2009), evidence from different case studies (e.g., preference for fishes or corals) (e.g., Grafeld et al., 2016; Williams and Polunin, 2000; Zunino et al., 2020) indicates that distinct or unique ecological attributes are important drivers of location-specific travel preferences (Polak and Shashar, 2013; Uyarra et al., 2009; Wielgus et al., 2003). In the case of the GBR, a high aesthetic value is attributed to assemblages of reef-building hard corals and abundant large and schooling fishes, considered by many visitors as 'the ultimate GBR aesthetic experience' (Marshall et al., 2019). Understanding drivers for such preferences and WTP for diving is therefore useful to predict how future changes in marine environments will shape the tourism sector of the GBR.

4.2. Effect of protection status designation

We found that divers would pay a A$14.5 premium to dive in a marine reserve in the GBR even when the reserve has the same ecological conditions as an unprotected area. However, as the ecological conditions improve inside the marine reserve, divers' WTP increases. This suggests that divers would pay to dive in marine reserve sites and, in general, for conservation.

When divers were asked to imagine that they are currently diving in a marine reserve in the Philippines with moderate biological conditions, and further asked how much they would be willing to pay a user fee to dive in a marine reserve with the same moderate biological conditions but in the GBR, the divers responded that they would be willing to pay A $14.3, which is not significantly different from the WTP of divers to dive from a fished area in the GBR to a marine reserve in the GBR (i.e., A $14.5). While it is clear that GBR divers placed a premium on the marine reserve designation of the GBR, it is unclear if the GBR divers would also placed a premium on the marine reserve designation of dive sites in the Philippines and that there is an A$14.3 difference in the premium placed by GBR divers on the GBR marine reserve (vs. the Philippine marine reserve). An earlier study in the Philippines suggests that divers place a premium on diving in marine reserves (Arin and Kramer, 2002). In particular, Arin and Kramer (2002) found that divers in the Philippines are willing to pay US$3.4 to US$5.5 to dive in marine reserves in the Philippines where fishing is prohibited. Diver experience may play a role in the premium divers placed on marine reserves in other locations (i.e., many of the GBR divers we surveyed may not have dived in the Philippines yet and may be subjected to information bias (Ajzen et al., 1996)). Further study is required to ascertain the difference in premium placed by divers on marine reserve designation.

Divers' WTP is further influenced by social factors, for example, the desire to create a positive environmental impact for the next generation (Peters and Hawkins, 2009). In Guam, it was estimated that divers would contribute a total of US$ 900,000 to projects that would improve reef conditions for them to enjoy (Grafeld et al., 2016). There is increasing evidence that people would be willing to pay for the conservation of marine biodiversity in the form of a user fee (Tonin, 2018). In Komodo National Park, it was estimated that visitors' WTP for user fees was 10 times higher than what they currently were paying, and their proposed small increase of user fees could demonstrate the potential for conservation from tourism (Walpole et al., 2001). In the GBR, the study conducted by Farr et al. (2016) estimated that visitors are willing to pay up to A$14.5 extra per visit to help improve water quality, a major threat due to agricultural land use. This was further explored by De Valck et al. (2022), who estimated that an annual contribution of A$24.5 from local households would generate A$46.9 million to support water quality improvement in the GBR. There is increasing evidence that people are willing to pay for conservation efforts, suggesting that the more familiar or closer they are to the issue, the more willing they are to take action. Divers have a high appreciation for good coral reef quality and are willing to pay more for conservation if better conditions are guaranteed. The surplus from the increase in user fees can be redirected to local economies, potentially supporting new management and policy efforts, assuming that the dive experience quality is maintained (Schuhmann et al., 2013).

4.3. Divers' perception of user fees

The imposition of a user fee to dive into the GBR Marine Park would likely be better received if its purpose is clear and explicitly stated. Studies have observed that acceptance of user fees is higher if the purpose and use of the generated revenue are explained to the payers (Casey et al., 2010), especially if such money is invested in the conservation or management of marine resources (Drew et al., 2022). The establishment of a small user fee could generate millions of dollars per year for management (Cabral et al., 2025; Vianna et al., 2018), and the negative perception of the fee could be minimized if revenue allocation is explained (Edwards, 2009). This was highlighted by dive operators in Southeast Asia and the Francophone Indo-Pacific Region, who emphasized how this transparency in using this revenue is essential for the acceptance of new or increased user fees (Depondt and Green, 2006a). Therefore, the implementation of a user fee system is likely to be successful if done with the collaboration of all interested parties (i.e., visitors, managers, and dive operators) (Terk and Knowlton, 2010). However, if divers (or visitors in general) are willing to pay, collection of user fees is not always implemented due to the government's concern about losing tourism demand (Wielgus et al., 2010). Studies have assessed whether divers would be willing to pay a user fee to access a marine reserve or a Marine Park, recording, in many cases, over 90 % positive answers (e.g., Mathieu et al., 2003; Yeo, 2004).

The majority of our surveyed divers had dived multiple times in the GBR. Therefore, divers' positive attitudes towards the user fee could be due to positive impressions and/or prior awareness of the Marine Park. Uyarra et al. (2010) explored divers' acceptance of increased user fees in Bonaire National Marine Park. They estimated that previous visitations of Bonaire and positive experiences of tourists were associated with higher total WTP and a higher acceptance of the user fee. This contrasts with findings from Kirkbride-Smith et al. (2016) who estimated lower WTP from repeat visitors. In Sipadan, Malaysia, Emang et al. (2020) reported that more experienced divers exhibit higher return visit rates and have increased sensitivity to coral reef quality. However, offering new divers' experiences could lead to repeated visits, eventually transitioning into the committed divers category, who are more invested in coral reef quality.

Marine reserves are key in environmental conservation and preservation. However, costs associated with their establishment, implementation, and continued persistence highly depend on market forces, and managers struggle to sustain these expenditures (Dharmaratne et al., 2000). MPAs can be funded directly by the central government (Becker and Choresh, 2006), public donations, or trust funds, however, these funding bodies tend to leave marine reserves with limited resources and to compete for funds (Peters and Hawkins, 2009). Furthermore, a lack of securing funds is identified as the main barrier to the successful management of marine reserves (Green and Donnelly, 2003). Some marine reserves have successfully reached economic stability through self-financing (Teh et al., 2008), such as through private management (Riedmiller, 2000) and/or user fees. Bonaire National Marine Park established user fees for divers in 1992, becoming the first self-financing Marine Park of the Caribbeans (Thur, 2010). Furthermore, when the user fee was established following a contingent valuation survey of its visitors, 92 % of the respondents found a user fee acceptable and were willing to pay the proposed rate of US$10 to enter the Marine Parks (Dixon and Scura, 1993). In many countries of Southeast Asia, Marine Parks funds are secured through diving user fees; however, this revenue is much lower than potential users' WTP (Depondt and Green, 2006a). A study conducted in the Florida Keys estimated that the management cost of the marine reserve constitutes only 1 %–2 % of the yearly revenue generated by the reserve, suggesting that the recreational benefits of the marine reserve managing program exceed its costs, providing evidence of economic viability for the implementation of user-based funding mechanisms to ensure the reserve is self-sustaining in the future (Bhat, 2003). In the Philippines, after two years of fee collection, the management body was able to collect the equivalent of 28 % of the yearly recurring costs and 41 % of the core costs of Tubbataha Reefs Natural Marine Park, showing how WTP studies can be used to introduce user fees and reach self-financing in the long-term (Tongson and Dygico, 2004).

Sustainable financing is a key factor limiting the successful implementation and upkeep of Marine Parks in numerous places. However, while high levels of in-principle acceptance of user fees among scuba diving tourists may be encouraging, there are multiple ethical and practical challenges to the implementation of such fees, which include consideration of procedural and distributional equity, as well as collection mechanisms. It is likely that different approaches are necessary for different locations/destinations, and the engagement and support from dive tourism businesses will be a critical factor for the design and implementation of a sustainable user fee system. In several locations user fees have been integrated into the ticket price for dive tours and collected directly by dive operators (Depondt and Green, 2006b; Peters and Hawkins, 2009). In the GBR Marine Park, the current Environmental Management Charge provides a precedent and an established collection mechanism (Great Barrier Reef Marine Park Authority, 2024a); however, at present, industry and public preferences and support for tiered pricing to access different parts of the Marine Park remain unknown.

4.4. Reef protection implications

New revenue generated from scuba diving user fees could potentially support initiatives and activities to bolster coral reef resilience (e.g., coral restoration and assisted adaptation techniques, coral predator removal). While new user fees can potentially offer sustained financial support for coral reef protection initiatives, tourism in the GBR (and in other coral reef destinations) is already promoting and actively contributing to reef conservation in multiple ways, through participation in citizen science, crown-of-thorns starfish control, coral restoration projects, and through education of Reef visitors and advocacy for Reef protection (Curnock et al., 2023; Hein et al., 2020). The considerable costs associated with such initiatives in the GBR to date have largely been borne by government-funded programs (e.g., the Tourism Reef Protection Initiative: https://www2.gbrmpa.gov.au/our-work/programs-and-projects/tourism-reef-protection-initiative) with in-kind support provided by willing tourism operators. While the application of new user fees for scuba diving tourism might be regarded as undesirable by some stakeholders, they might also offer an incentive for dive tourism businesses, providing financial support for their involvement in coral reef protection initiatives.

Scuba dive tourism in the GBR and coral reefs elsewhere has the potential to partially or fully finance long-term storage of blue carbon, further supporting local and global climate initiatives. A recent assessment of 50 World Heritage marine sites suggests that GBR holds the biggest stock of blue carbon at 1.8 billion tonnes of CO_2-equivalent, mainly from its seagrass beds, mangroves forest, and tidal marshes (UNESCO, 2020). These ecosystems support reef fish biomass and biodiversity and protect coral reefs from sedimentation by being the first line of defense from terrestrial runoff, with high reef fish biomass, biodiversity, and coral reef quality associated with higher scuba divers' WTP. With about 400,000 divers participating in scuba diving in Australia annually and the GBR being a top diving destination (Scuba Diving in Australia, 2022), there is high potential for monetizing these improved WTP for improved diving quality, with proceeds of this additional revenue to support climate change programs and the protection and restoration of blue carbon.

4.5. Conclusion

In this study, we assessed how changes in coral and fish attributes impact divers' willingness to pay (WTP) when diving in the Great Barrier Reef (GBR) Marine Park. This is important in the context of climate change and reef management prospects. We also assessed whether divers place a premium for the protection designation or marine reserve name and whether explicitly stating the intended use of user fees impacts WTP. We found that divers of the GBR Marine Park would pay a premium to dive in a marine reserve even when the biological conditions are the same as those in an unprotected dive site. Divers' WTP was influenced mostly by high coral cover and high fish abundance and diversity, as well as demographic profile and diving experience. Finally, we found divers would respond to the introduction of a user fee with greater positivity if the intended use of the revenue was shared with them. Given that our study is limited to just one recreational activity in the multiple-use GBR Marine Park, further studies of WTP among other Reef user groups will be necessary to inform future evaluations or decisions about user fees. Given the high number of visitors undertaking trips daily to the GBR for recreational purposes and the big economic influence the GBR tourism industry has on the region's economy, an improved understanding of the preferences and WTP among other recreational/commercial activities may be important for future Reef management. If a user fee is used as a tool to generate more revenue from the marine park, the purpose of the fee should be explicitly stated and shared with the resource users.

CRediT authorship contribution statement

Alessia Costa: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Matthew Curnock:** Writing – review & editing, Supervision. **Reniel B. Cabral:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2025.125139.

Data availability

Because the dataset used in this work contains personal information, requests for access to the dataset should be made by emailing the corresponding authors.

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