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Turtle Economic Value: The non-use value of marine turtles in the Asia-Pacific region

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ABSTRACT

Marine turtle species in the Asia-Pacific region face loss of habitat, population decline and serious risk of extinction. Understanding the associated loss in human welfare can motivate conservation finance, policy reforms and other actions to protect and restore marine turtle populations. This paper estimates non-use values for marine turtles in the Asia-Pacific region using a large-sample ($n = 7765$) global household survey. The survey focused on six countries in the region (China, Fiji, Indonesia, Malaysia, the Philippines and Vietnam) but received responses from over 80 countries in total. A discrete choice experiment was used to elicit willingness-to-pay (WTP) for marine turtles, defined in terms of population trends (increasing, stable or declining) and species diversity (avoided extinctions). We find that a high proportion of households (82%) expressed a positive WTP for turtle conservation, and that the donation amounts are substantial. The median WTP for ensuring stable marine turtle populations, adjusted for demographic differences between the survey sample and the general population, is estimated at US $79 per household per year. A scenario analysis is used to estimate the economic welfare changes that would result from policy inaction (in which turtle populations continue to decline and two species become extinct) versus strong policy action (resulting in increasing turtle populations and no extinctions). The welfare loss that results from not acting is estimated to be US $40 billion per year, whereas the potential welfare gain from taking policy action to conserve, manage and protect marine turtles is estimated at US $55 billion per year. These results present a strong economic justification for governments across the region to align their environmental policies and budgets with Asia-Pacific peoples' stated WTP for turtle conservation.

1. Introduction

Many wild species, including marine turtles, face loss of habitat, population decline and, in some cases, extinction (IPBES, 2019; CBD, 2020). Understanding the associated loss in ecosystem services and human welfare can potentially motivate action and financing to protect and restore wild species populations (Dasgupta, 2021). To this end, there is a large and expanding number of studies that estimate the economic value of wild species (Loomis and White, 1996; Richardson and Loomis, 2009; Amuakwa-Mensah et al., 2018; Subroy et al., 2019). This literature covers a diverse array of species – from African elephants (Wang et al., 2018) to wild turkeys (Stevens et al., 1991); and a diverse range of economic benefits that wild species provide, including provisioning services (Kibria et al., 2017; Nunes et al., 2019), regulating services (Gallai et al., 2009; Chami et al., 2020) and cultural services (Kido and Seidl, 2008; Kontogianni et al., 2012; Naidoo et al., 2016).

Marine turtles are well represented in the economic valuation literature, with studies estimating the value of green turtles (Teh et al., 2018; Jin et al., 2010; Rathnayake, 2016; Tisdell and Wilson, 2001; Fan, 2008), leatherback turtles (Cazabon-Mannette et al., 2017; Rudd, 2009; Wallmo and Lew, 2012), hawksbill turtles (Tisdell, 2005; Teh et al., 2018), loggerhead turtles (Stithou, 2009; Stithou and Scarpa, 2012) flatback turtles (Tisdell and Wilson, 2001) and olive ridley turtles (Jin et al., 2010; Teh et al., 2018). Troëng and Drews (2004) provided a

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global assessment of the direct consumptive use (food and materials), non-consumptive use (ecotourism) and non-use values derived from marine turtles through a synthesis of 18 case studies and a survey of conservation organisations' expenditure on turtle conservation. Non-use values may be related to altruism (maintaining an ecosystem for others), bequest (for future generations) and existence (preservation unrelated to any use) motivations. The aggregation across relevant use and non-use values provides a measure of total economic value (TEV). Their results provide a partial estimate of the total economic value of marine turtles but are, to some extent, outdated due to changes over time in human use of and preferences for marine turtles. In particular, Troëng and Drews' estimation of non-use values is conservatively based on actual conservation expenditure, which does not necessarily fully capture the welfare loss that people experience due to species extinctions or population declines. This study provides an updated valuation of marine turtles at a regional scale to inform current and future conservation planning and decision-making.

We use a Discrete Choice Experiment (DCE) to estimate the non-use values provided by marine turtles in the Asia-Pacific region. This regional focus is motivated by the high diversity, level of threat, and rapid population decline of marine turtle species in the region (Wallace et al., 2011; Mazaris et al., 2017). Marine turtles are present in many parts of the world, nest in over 80 countries, and live in the coastal waters of >140 countries (Seminoff et al., 2015). Worldwide, marine turtle species are classified as vulnerable (loggerhead, olive ridley and leatherback), endangered (green) or critically endangered (Kemp's ridley and hawksbill) (IUCN, 2021). Sub-population level assessments are not available for all species, but the West Pacific leatherback and the South Pacific loggerhead sub-populations have been classified as critically endangered (Tiwari et al., 2013; Limpus and Casale, 2015).

The remainder of this paper is structured as follows: Section 2 describes the methods and data, specifically the DCE and survey implementation; Section 3 presents the results of the DCE and estimated aggregate WTP; Section 4 develops a scenario analysis of welfare change attributable to alternative policy developments; and finally, Section 5 provides a discussion and conclusions.

2. Methods and data

To obtain quantitative measures of the existence and bequest values that people derive from marine turtles, we used the discrete choice experiment (DCE) method. This is a stated preference method that uses a representative public survey to elicit the preferences or WTP of respondents for specified changes in a good or service (Bateman et al., 2002). In the fields of market research and economics, the DCE method is widely used to obtain information on public preferences that are otherwise not directly observable in consumer behaviour (Hensher et al., 2005; Johnston et al., 2017).

In practical terms, a DCE involves asking survey respondents to make repeated choices between alternative multi-attribute descriptions of a good or service represented on a choice card. By observing the trade-offs that are made between different attributes, it is possible to estimate their relative values (Hanley et al., 2001). By including one attribute that represents a monetary payment on the part of the respondent, it is also possible to compute their WTP for changes in other attributes (Pearce and Özdemiroğlu, 2002). In this study, respondents were asked to choose between alternative scenarios for future marine turtle population levels and species diversity that would be financed through their (hypothetical) monthly donations over a period of 10 years to a fund dedicated to turtle conservation in the Asia-Pacific region. By analysing the trade-offs that respondents made between alternative conservation outcomes and the magnitude of their donations, we were able to quantify their potential WTP for each attribute of turtle conservation status.

2.1. Experimental design

The experimental design of a DCE defines the attributes used to describe alternative conservation outcomes, the levels that each attribute can take, the combination of attribute levels in each option, the combination of options in each choice card, and the number of separate choices respondents are asked to make.

The overarching selection criteria for attributes were, firstly, that they should represent different aspects of turtle conservation status, in line with the central objective of the study. Secondly, the attributes were functionally independent to satisfy a requirement of the DCE framework (Hensher et al., 2005); and, thirdly, the attributes were unambiguous, so as to not unintentionally increase the level of unobserved variance. The process of developing the survey questionnaire and testing of attributes used in the DCE is described in Brander et al. (2021).

The experimental design in the present study included three attributes comprising two environmental characteristics and one payment vehicle. The turtle *population* attribute was described by three levels (declining, stable and increasing); while the *diversity* of marine turtles was described by four levels (0, 1, 2 and 3 species become extinct). The *payment* attribute was defined by seven levels (USD 0, 2, 5, 10, 15, 20 and 30). The estimated value function for threatened and endangered species developed by Amuakwa-Mensah et al. (2018) was used to derive a preliminary estimate of mean household WTP for marine turtles, which served as a starting point for defining the payment amounts in our study.[1]

The monthly payments were described as voluntary contributions over a 10-year period to a dedicated conservation fund, which would be used to pay for conservation measures, such as turtle-safe fishing gear, protection of turtle habitats, sand-cooling structures, turtle nest protectors, and rangers to protect turtle nests from poaching. A voluntary donation was deemed to be the most realistic, acceptable and widely applicable payment mechanism across the diverse surveyed countries but is recognised as prone to hypothetical strategic bias, since it is not mandatory (Johnston et al., 2017). We note, however, that Jin et al. (2010) compared a mandatory addition to the electricity bill with voluntary contributions to pay for marine turtle conservation and found little difference in the resulting WTP estimates. They only found a statistically significant difference in their Vietnam sample, in which the mandatory payment resulted in higher WTP than voluntary contributions.

The survey was administered using seven versions targeting different populations: an international version in English and Spanish distributed globally; and six country-specific versions for China, Fiji, Indonesia, Malaysia, the Philippines and Vietnam, respectively. In the country-specific versions of the choice cards, the currency of the payment attribute was converted from USD to national currencies using market exchange rates and adjusted in proportion with differences in per capita income between the US and each country. The income adjustment was made in order to scale the payment levels in line with average household incomes in each country. Converted amounts in national currencies were rounded to whole numbers with clear intervals between amounts (e.g., multiples of 5000 in the case of Indonesia and Vietnam). The donation levels for each survey version are presented in Table 1.

An orthogonal fractional factorial experimental design defining 60 choice cards was generated using Sawtooth software.[2] Each card shows three options representing different future turtle conservation outcomes,

[1] The parameter values included in the value function were: "Reptile"; "Endangered and high charisma"; "Trust fund" (payment vehicle); and "Monthly payment" (frequency of donation). The response rate was set equal to the sample mean (61%) and the sample size to 3000 responses. Using the value function developed by Amuakwa-Mensah et al. (2018), these parameter values give an estimated WTP/household/year of US $10.77.

[2] https://www.sawtoothsoftware.com/

Table 1
Income-adjusted donation levels in alternative currencies.

Other Countries	China	Malaysia	Indonesia	Vietnam	Philippines	Fiji
USD	CNY	MYR	IDR	VND	PHP	FJD
0	0	0	0	0	0	0
2	2	2	5000	5000	15	1
5	5	5	10,000	10,000	30	2
10	10	10	20,000	20,000	65	5
15	20	20	40,000	40,000	100	7
20	40	40	60,000	60,000	140	10
30	60	60	80,000	80,000	200	15

together with a corresponding payment amount. Respondents were asked to select their preferred option out of three; and then asked to repeat the choices over a total of six cards. Of the three options presented on each choice card, one option (Option C) was held constant across all cards and represented a future (business as usual) scenario, in which no donation was made and the environmental attributes took the lowest possible levels (i.e., declining turtle populations and three species go extinct). These attribute levels also appear in the alternative policy options (Options A and B) to enable their marginal utilities to be estimated. This constant option provided respondents with an opt-out if they did not wish to pay for additional turtle conservation.

2.2. Choice representation

The attribute levels defining each option were represented on choice cards using pictograms to provide respondents with a visual support for understanding the differences between the three options. A sample choice card from the international survey in English is provided in Fig. 1. This representation was tested for comprehension through stakeholder consultation and pilot surveys and found to effectively communicate the levels of each attribute. The six choice cards seen by each respondent were randomly selected from a total set of 60 choice cards.

Before being asked to choose their preferred option on each choice card, respondents were reminded to consider carefully how much money they could actually afford to contribute each month and where that money would come from, given other expenses in their monthly budget. This reminded respondents that their donations were constrained by their income and served to frame the conservation decision as a trade-off with other uses of income. The full survey instrument is available in supplementary information.

2.3. Survey implementation

The survey was implemented using an online platform during the period 31 March to 10 August 2020 and distributed in seven versions: an international version in English and Spanish, distributed by email through a variety of professional, academic and personal networks; five country-specific versions for China, Indonesia, Malaysia, the Philippines and Vietnam in national languages, distributed by email using a panel survey company (Ipsos); and a country-specific version for Fiji, in English, conducted as a face-to-face intercept survey. The Fiji survey was administered by a team of WWF staff and volunteers using an offline copy of the survey downloaded onto tablets and smartphones. The sample in Fiji was obtained using convenience sampling in public spaces in the capital Suva. It is recognised that the differences in sampling and survey administration have implications for the responses obtained, representativeness of the samples, and the overall results. In particular, the distribution of the international version is through networks linked to the researchers and may therefore be biased towards respondents with a greater likelihood to make donations and willing to pay larger amounts. In the case of Fiji, interviewer bias effects may occur during the face-to-face interviews. The sampling approach in China, Indonesia, Malaysia, the Philippines and Vietnam is a random selection from the Ipsos panel in each country.

2.4. Value transfer for aggregation and scenario analysis

Value transfer methods were used to estimate aggregate WTP for turtle conservation in the Asia-Pacific region and the welfare effects of explorative conservation scenarios. Value transfer, or benefit transfer, is the use of research results from existing primary studies at one or more locations (study sites) to predict welfare estimates or related information at other locations or policy contexts (policy sites) (Navrud and Ready, 2007). We make use of a value function approach in which the survey and DCE data are used to estimate two predictive functions: 1. To predict the proportion of households in each country that are in principle WTP for turtle conservation; 2. To predict the median WTP per household in each country. We test the validity of this approach and scale of transfer errors by computing the mean absolute percentage error across the six target countries (Johnston et al., 2021).

2.5. Evaluation of best practices

To the greatest extent possible, the design and implementation of the valuation approach and aggregation conforms to best practice guidance (Johnston et al., 2017, 2021) and diverges in some aspects only in consideration of the specific context of this study. To summarise and evaluate the key methodological features: the survey instrument and experimental design underwent qualitative and quantitative pretesting through focus groups and random sampling of the target populations; a clear and credible description of the baseline as a reference point for the valued environmental change is provided; the selection and description of the attributes and change being valued is based on respondents' understanding of the good; the experimental design makes use of prior empirical research and considers respondents' cognitive abilities and familiarity with the good; the survey procedure avoids deception and any negative consequences for respondents; the survey implementation uses a mix of survey modes (online and face-to-face) determined by availability of respondent panels across target countries; all survey modes make use of visual representations of the valued good; sample representativeness is assessed and addressed in the analysis; incentive compatibility is considered in the design of the choice question, which uses a multinomial format between a baseline alternative and two alternatives that describe changes from the baseline; the payment vehicle (voluntary donation) was selected to be realistic, credible, familiar, but is not binding for all respondents; ancillary questions were used to obtain information on familiarity with the valued good and choice process; ex ante procedures were used to enhance validity in the form of a reminder of household budget constraints and consequentiality of the responses; the analysis of choice data reflects the purpose of the valuation, heterogeneity of respondent preferences, and alternative assumptions on the structure of responses; reported welfare estimates include estimates of central tendency, dispersion and confidence intervals; the generalisability of the value estimates is assessed and the approach to aggregation and value transfer is fully explained; and finally construct and criterion validity is assessed.

3. Results

3.1. Survey sample

The six focus countries and respondent locations are represented in Fig. 2. In total, 10,548 respondents accessed one of the online survey instruments hosted by the Alchemer survey software platform.[3] Of these, 7765 respondents (74%) completed the questionnaire.

The sample is reasonably dispersed across age and income groups,

[3] https://www.alchemer.com/

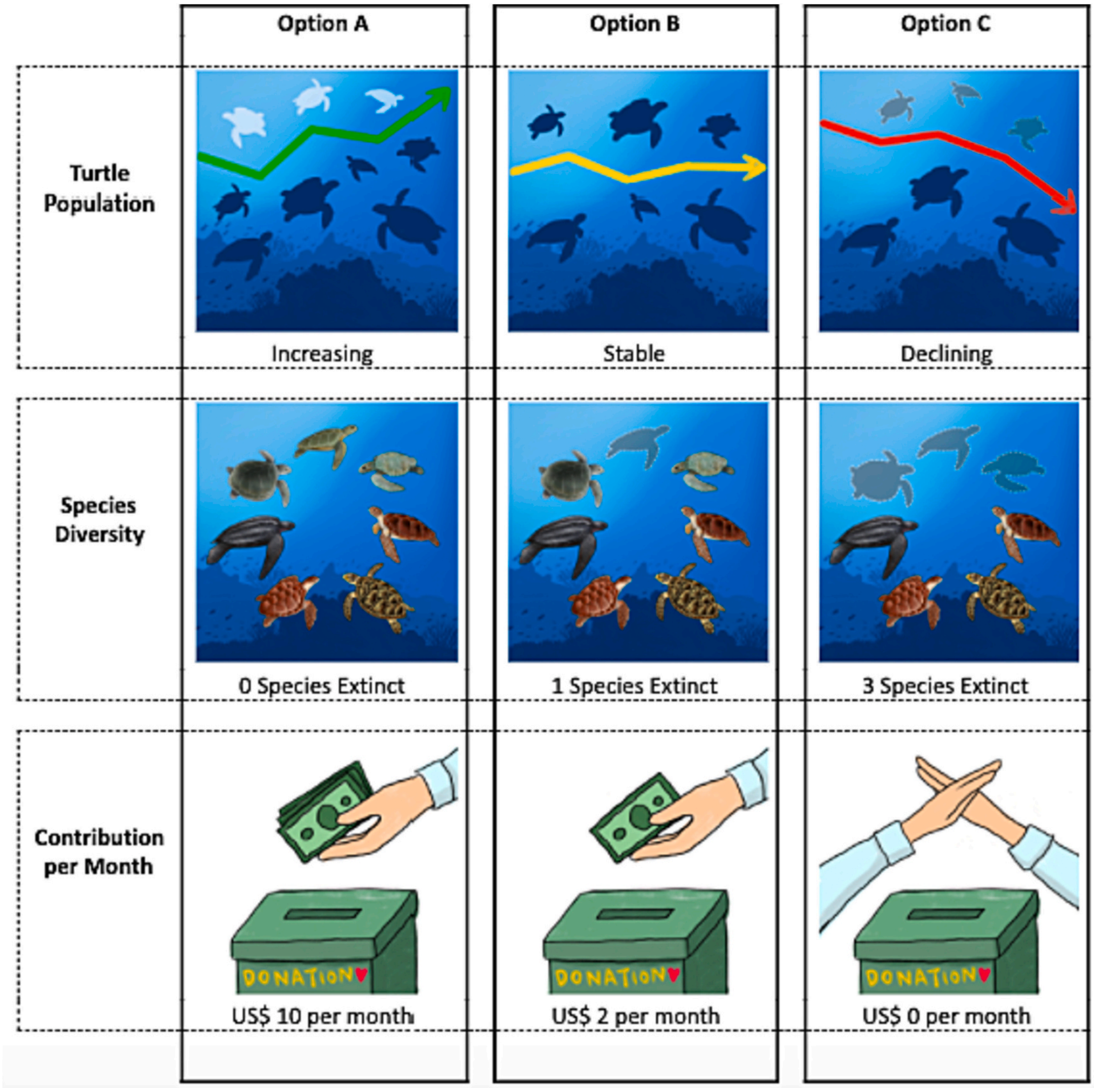

Fig. 1. Sample choice card.

and balanced by gender, but is biased towards people with a university education and those living in major urban areas. This has implications for the representativeness of the sample and we attempt to account for this when extrapolating the WTP results to the general population. Regarding direct experience of marine turtles, 43% of the sample indicated they had seen a live marine turtle in either the wild or in a zoo/aquarium. A detailed description of respondent characteristics and responses is provided in Brander et al. (2021).

3.2. Choice analysis results

Data from the choice experiments were analysed using a mixed logit (MIXL) model (Revelt and Train, 1998). The MIXL model is a generalisation of the standard logit model that accounts for the possibility that the preferences determining choices differ between individuals. MIXL models generally provide a better goodness-of-fit to data than standard logit models (e.g., Hess et al., 2012).

We assumed that the estimated random parameters were normally distributed, since we had no expectation for the sign of the coefficient. The parameter for the variable 'payment', which we assumed to have a negative lognormal distribution to ensure a negative coefficient for cost. We normalised the alternative-specific constants on the opt-out option, to capture any unobserved biases for conservation actions over the status quo.

The choice experiment included a categorical variable for the trend in turtle population, which could decline, remain steady or increase. The estimated model contains two variables that are both normalised on the possibility of a declining turtle population to highlight relative preferences for stable or increasing populations, each relative to a declining population.

The estimated model assumes linear preferences for, or rather aversion to, the number of species going extinct. A quadratic specification was also explored but did not support the hypothesis of non-linear preferences for species extinctions.

We initially considered country-specific shifts in the 'payment' attribute for the six target countries, non-target countries in East Asia and the Pacific, Europe, North America and respondents from the other countries. However, successive model iterations indicated that the shifts for non-target countries were not significantly different from each other. Therefore, non-target countries were grouped to express country-specific shifts in the estimated payment coefficients of target countries.

We estimated an extended model, in which the parameter for 'payment' is interacted with age (in years) and household income (in US $1000 per month). These socio-economic characteristics are included as linear variables. This extended model enables further consideration of country-specific data in WTP estimations, particularly when applying

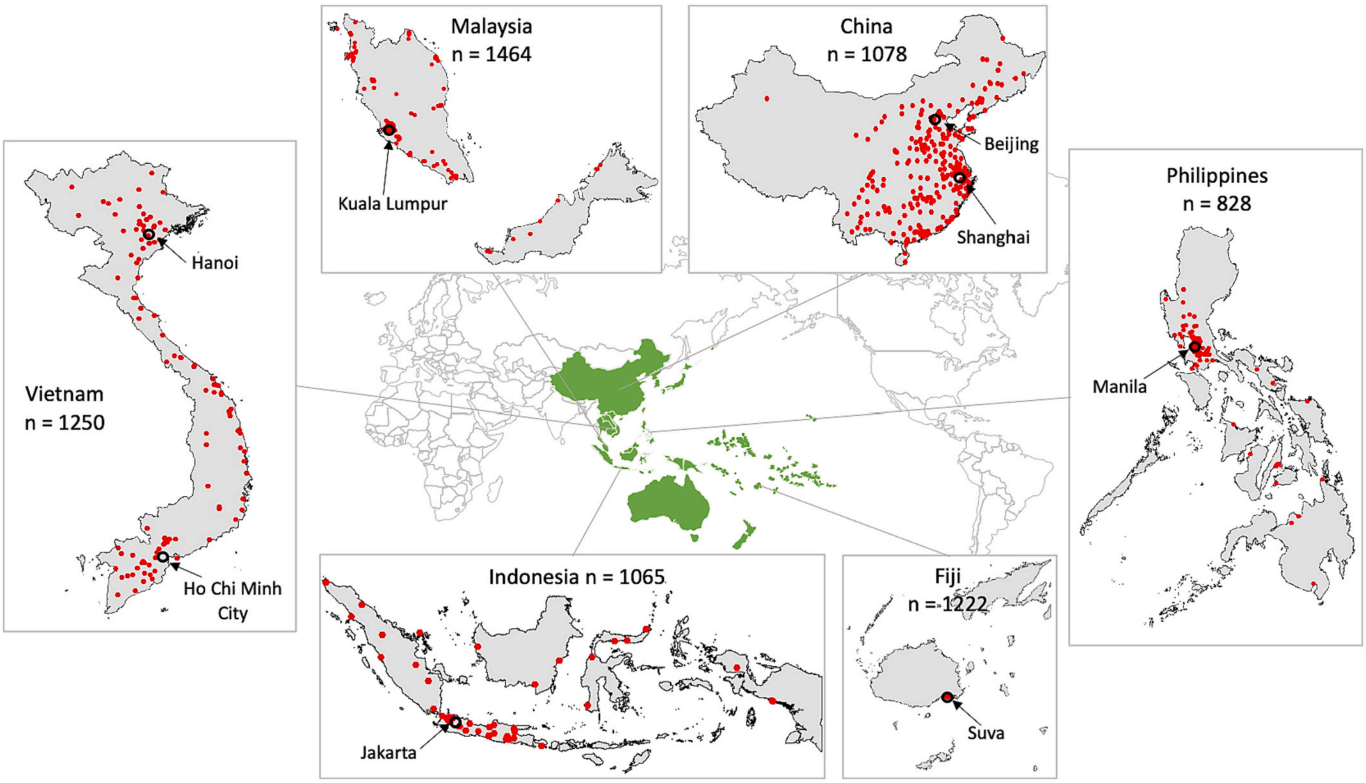

Fig. 2. Asia-Pacific region and target countries for survey distribution, showing the geographic spread and number of respondents in each country (responses from other countries are not shown).

the model results to non-target countries, which share a payment coefficient estimate.

The software used to estimate the choice models was the Apollo package version 0.2.4 (Hess and Palma, 2019) for use with R version 4.0.5 (R Core Team, 2018). To estimate WTP and confidence intervals, we used procedures outlined by Train (2009) and by Krinsky and Robb (1986).

Table 2
Estimated choice model.

	Coefficient	Standard error	Significance
Option A	1.976	0.049	***
Option B	1.977	0.047	***
Population steady			
Mean	0.653	0.027	***
s.d.	0.709	0.040	***
Population growing			
Mean	0.848	0.031	***
s.d.	1.062	0.039	***
Species loss prevention			
Mean	0.370	0.013	***
s.d.	−0.642	0.016	***
Payment			
Mean	−4.661	0.113	***
s.d.	−2.709	0.082	***
Country effects			
China	−0.026	0.044	
Fiji	−1.980	0.175	***
Indonesia	0.797	0.054	***
Malaysia	0.923	0.109	***
Philippines	1.287	0.159	***
Vietnam	0.689	0.130	***
N	37,523		
Log-likelihood	−29,919.7		
Adj. ρ^2	0.274		

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The basic version of the estimated choice model is given in Table 2. Note that the sample size (N) is the total number of observed choices (i.e. the number of respondents multiplied by number of choice cards seen per respondent). All estimated coefficients are significant at the 1% level. Model fit, as indicated by the adjusted ρ^2 (McFadden, 1974), is good, at 0.27.

The alternative specific constants (ASC) for options A and B are both positive, indicating respondents were more likely to select a conservation option than the constant "business as usual" option. Furthermore, the estimated ASC coefficients were of similar size, indicating the absence of unobserved biases in respondents' choices for Options A and B.

The estimated coefficients for a steady turtle population, an increasing turtle population and preventing turtle species loss all have the expected positive sign that indicates respondents prefer options with lower environmental damage. The estimated coefficient for payments to finance conservation effort was comparatively large and negative, indicating that higher donation amounts reduce the probability of selecting an option.

The estimated country-specific shift for China on the payment variable was not statistically different from the parameter estimated for the reference category of non-target countries, indicating that Chinese respondents have a similar level of WTP for turtle conservation as respondents in non-target countries. Most country-specific shifts in the payment variable indicate that respondents were more sensitive to the payment variable in their choices than respondents from China and non-target countries. The choices modelled for Fiji are the exception, with the estimated model indicating that Fijian respondents were much less affected by the payment variable and, as a consequence, the WTP estimates for Fiji are relatively high.

3.3. Estimates of existence and bequest values for marine turtles

The results of the choice model were used to estimate WTP for changes in the turtle population trend and the number of avoided species extinctions. The estimated WTP values account for the estimation errors and standard deviations of the mean estimated coefficients. This was achieved by simulating 50,000 randomly determined combinations of estimation errors and standard deviations for the mean estimated coefficients and computing WTP as the ratio of each turtle attribute coefficient and the payment coefficient. Due to the assumed negative lognormal distribution of the payment parameter, mean WTP was significantly higher than the median value, due to small numbers of exceedingly high WTP values. We therefore report the median WTP to avoid the influence of such non-representative WTP values. The estimated median WTP for the six target countries and the "rest of the world" are presented in Table 3. The estimated WTP for Fiji is unexpectedly high and possibly reflects the influence of the face-to-face mode of survey implementation.

The WTP amounts for a "stable population" and "increasing population" are defined relative to the current situation, which is a declining turtle population in the Asia-Pacific region. In other words, the values express the amount that households are willing to pay to achieve a change from declining to a stable or increasing turtle population. It is notable that the median WTP for an increasing turtle population is only marginally higher than the median WTP for a stable population. This suggests that people are most concerned about, and willing to pay to avoid, a declining population.

The median WTP for "species diversity" is defined per avoided turtle species extinction. These values are consistently lower than those estimated for improving the population trend, which suggests that people are more concerned about ensuring a healthy population of marine turtles than they are about the number of different turtle species that exist.

3.4. Aggregate existence and bequest values for marine turtles

To arrive at an aggregate measure of existence and bequest values across the Asia-Pacific region, for each country we estimated the number of households that would be willing to donate money for marine turtle conservation and the median amount that each household would be willing to pay.

The proportion of survey respondents who indicated they were willing, in principle, to donate funds for marine turtle conservation is 82% (ranging from 70 to 92%). The sample of respondents, however, is not representative of the general population of the region: respondents were generally younger, more educated and had higher incomes than average for their country. To account for these differences and estimate the number of households in each country that would be willing to pay for marine turtle conservation, we estimated a logistic regression to explain variation in respondents' indication that they were, in principle, willing to pay a positive amount. The explanatory variables included in the regression model were age, gender, income and a dummy variable for each target country. The estimated model is reported in Table 4. The overall explanatory power of the model is low (Nagelkerke $R^2 = 0.073$) but we obtained statistically significant coefficients for age (a negative relationship, indicating that older people are less likely to say they are willing to donate) and income (a positive relationship, indicating that people with higher incomes are more likely to say they are willing to donate). We found no statistically significant difference between men and women in terms of their in-principle WTP for marine turtle conservation.

To estimate the proportion of households in each country that would be willing, in principle, to donate money to turtle conservation, we applied the characteristics of a representative household for each country (using median values for age of respondent and income) to the regression model described above. Countries with younger and wealthier populations (e.g., Guam and Brunei) had a higher proportion of households that were willing to donate; whereas countries with older and poorer populations (e.g., Palau) had a lower proportion of households willing to donate.

To determine the median WTP per household in each country, we estimated a separate model using the choice data that included interaction terms between the payment amount and respondents' age and income. This model was used to predict the median WTP of a representative household by inputting the median age and income for each country. We tested the accuracy of predicted values by computing the mean absolute percentage error (MAPE) across the six target countries. The MAPE is 23% for WTP for species diversity, 25% for WTP for obtaining an increasing turtle population, and 27% for WTP obtaining a stable turtle population. This degree of transfer error is relatively low compared with other international value transfers reported in the literature (Lindhjem and Navrud, 2008; Kaul et al., 2013; Bateman et al., 2011; Johnston et al., 2021).

For each country, the median WTP of a representative household was then multiplied by the estimated number of households in that country that are likely to be willing to donate money for marine turtle conservation. We conservatively used the lower bound of the 95% confidence interval of median annual household WTP for an improvement in the marine turtle population trend, from declining to stable. This yielded an estimate of the total annual WTP for each country. The results suggest that 577 million households across the Asia-Pacific region would be collectively willing to pay US $45.7 billion annually over a 10-year period for an improvement in marine turtle populations (from declining to stable). This is a large sum but is equivalent to just 0.2% of total household income in the region (World Bank, 2020). Country level estimates of annual WTP are reported in Annex 1. Due to its large population, China accounts for two-thirds of the estimated total WTP for marine turtle conservation.

Table 3
Estimated median WTP for improvements in marine turtle conservation status in the Asia-Pacific region (USD/household/month; 2020 price levels; 95% statistical confidence intervals in parentheses).

	Stable population	Increasing population	Species diversity
China	33.57 (26.48–41.83)	38.33 (31.13–46.55)	12.21 (10.12–14.56)
Fiji	240.25 (165.48–332.48)	274.17 (192.9–373.54)	87.29 (62.64–117.14)
Indonesia	14.71 (11.95–17.86)	16.82 (13.83–20.23)	5.36 (4.45–6.37)
Malaysia	12.99 (10.28–16.13)	14.84 (12.09–17.93)	4.73 (3.9–5.67)
Philippines	9.07 (6.73–11.87)	10.36 (7.83–13.37)	3.3 (2.53–4.22)
Vietnam	16.43 (12.71–20.78)	18.77 (14.88–23.25)	5.98 (4.79–7.36)
Other countries	32.68 (26.11–40.28)	37.31 (30.85–44.65)	11.89 (10.03–13.94)

Table 4
Logistic regression model for WTP in principle (dependent variable: 0 = not willing to pay; 1 = willing to pay).

	Coefficient	Standard Error	Significance
Age	−0.028	0.003	***
Female	−0.017	0.069	
Income (ln)	0.336	0.032	***
China	0.656	0.139	***
Fiji	0.929	0.164	***
Indonesia	0.237	0.127	**
Malaysia	0.225	0.122	**
Philippines	0.768	0.145	***
Vietnam	0.763	0.136	***
Constant	−0.059	0.255	
N	7746		
−2 Log likelihood	5642.845		
Nagelkerke R^2	0.073		

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

3.5. Scenario analysis

As a guide for decision-making and investment, this section analyses the economic welfare impacts of alternative turtle conservation scenarios. The changes in the non-use value of marine turtles under "Policy Inaction" and "Policy Action" scenarios are compared to current trends to estimate the welfare cost of taking no action, versus the potential welfare gain of taking action to conserve marine turtles (see Table 5 for scenario descriptions).

These scenarios are explorative, "what if" storylines and are not based on predictive modelling of turtle populations and extinctions. It is important to note that the term "Policy Action" implies not only the creation of evidence-based turtle conservation policy, but also subsequent implementation, enforcement and sufficient compliance to improve the survival of marine turtle species and populations. The time horizon for the scenario analysis reflects a long-term perspective on the future of marine turtles, over which population trends can be influenced and/or extinctions of turtle species may occur.

Applying the same approach as for the aggregation of existence and bequest values, we estimated the WTP per representative household for each country in the Asia-Pacific region for the changes in marine turtle populations and extinctions described for each scenario. For the Policy Inaction scenario, we multiplied the 95% lower bound estimated median WTP to avoid the loss of a turtle species for a representative household in each country by two (the number of turtle species that are lost under this scenario). For the Policy Action scenario, we used the lower bound estimated median WTP to see a change from declining to increasing marine turtle populations for a representative household in each country. These household-level WTP amounts were then multiplied by the estimated number of households that were willing to donate in each country, to derive the total welfare effects of each scenario nationally.

The results for Asia-Pacific countries are presented in Table 5 and show large welfare losses from allowing marine turtles to become extinct due to policy inaction; and even larger welfare gains from taking policy action to enable marine turtle populations to increase. The total welfare loss across the region, as a consequence of not acting on marine turtle conservation, equates to US $39 billion per year, whereas the welfare gain from taking policy action to conserve, manage and protect marine turtles is US $54 billion per year.

Table 5
Scenario descriptions.

Scenario	Description
Current	This scenario describes the current trend ("business as usual") in which no marine turtle species extinctions have occurred but populations in the Asia-Pacific region are declining.
Policy Inaction	This scenario represents a situation with no additional conservation intervention or regulatory enforcement. Marine turtle populations continue to decline and two species become extinct.
Policy Action	This scenario describes a future in which conservation interventions are successful, resulting in increasing turtle populations and no species extinctions. Indicative conservation interventions include: – National action plans to mitigate threats to marine turtle populations, affording species and their habitat more protection; – The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) introducing a total ban on the international trade in turtle products, which is enforced by all Parties to the Convention (i.e., signatory governments); – Parties to the Convention on the Conservation of Migratory Species of Wild Animals (CMS) agree to and implement effective conservation management plans for migratory marine turtles; – The ratification, by major seafood producers and importers, of an Agreement on Port State Measures (PSMA) to prevent, deter and eliminate illegal, unreported and unregulated fishing (IUU); and – Achievement of the UN Sustainable Development Goal relating to sustainable fisheries, IUU fishing and marine protection (SDG14).

Table 5
Welfare changes due to policy inaction and action for marine turtle conservation (USD/year; 2020 price level; 000's).

Country	Policy Inaction (Declining turtle populations and two species become extinct)	Policy Action (Increasing turtle populations and no extinctions)
American Samoa	−803	1109
Australia	−667,734	915,838
Brunei	−6027	8282
Cambodia	−263,841	365,025
China	−26,936,808	36,902,649
Cook Islands	−302	414
Fiji	−5928	7887
French Polynesia	−5239	7170
Guam	−3576	4908
Hong Kong	−142,194	193,895
Indonesia	−2,914,056	4,184,742
Japan	−2,612,433	3,565,464
Kiribati	−1625	2249
Macau	−13,455	18,383
Malaysia	−349,041	502,149
Marshall Islands	−759	1054
Micronesia	−1551	2145
Nauru	−136	188
New Caledonia	−5798	7944
New Zealand	−117,187	160,289
Niue	−43	59
North Korea	−310,894	427,080
Northern Mariana Islands	−1225	1678
Palau	−371	509
Papua New Guinea	−145,873	202,507
Philippines	−894,369	1,325,291
Samoa	−2400	3333
Singapore	−118,870	162,834
Solomon Islands	−10,704	14,905
South Korea	−1,209,412	1,654,621
Taiwan	−395,388	540,466
Thailand	−1,075,138	1,473,299
Timor-Leste	−21,190	29,499
Tokelau	−23	32
Tonga	−1622	2251
Tuvalu	−151	210
Vanuatu	−5681	7907
Vietnam	−1,332,639	1,903,186
Wallis and Futuna	−182	251
Asia-Pacific region	−39,574,671	54,601,702

4. Discussion and conclusions

Asia-Pacific households appear to be willing to pay substantial sums to prevent marine turtle populations from declining and species going extinct. The median WTP to ensure stable turtle populations is estimated to be US $79 per household per year, which includes an adjustment to account for differences between the survey sample and the general population in each country.

To put our estimated values into context, we made a comparison with the results of 305 separate valuations of household WTP to conserve various wildlife species, obtained from 74 published studies. A summary of these values is provided in Annex 2. These valuations cover a range of different terrestrial and marine species from around the world and include birds (e.g., griffon vultures – Becker et al., 2005; bald eagles – Boyle and Bishop, 1987; northern pintails – Haefele et al., 2019); fish (e.g., coho salmon – Bell et al., 2003; whale sharks – Indab, 2016; shortnose sturgeons – Kotchen and Reiling, 2000); reptiles (e.g., green turtles, Teh et al., 2018; loggerhead turtles – Whitehead, 1992); and mammals (e.g., lions and gorillas – Morse-Jones et al., 2014; Asian elephants – Nabangchang, 2008; African elephants – Poufoun et al., 2016; black rhinoceros – Lee and Du Preez, 2016; grey whales – Loomis and Larson, 1994). The split of valuation estimates across terrestrial and marine species is approximately even. To facilitate comparison across value estimates, we standardised the reported WTP to USD/household/year at 2020 price levels.

Our estimates of household WTP for marine turtle conservation in the Asia-Pacific region are similar in magnitude to the mean household WTP for coral and mammal conservation, and somewhat higher than the mean household WTP for reptiles. This is in contrast with the findings of Lindhjem and Tuan (2012), who observe WTP for marine turtles to be significantly lower than for mammals in a meta-analysis of species and nature conservation values for Asia and Oceania. Our estimate of household WTP for marine turtle conservation in the Asia-Pacific (USD 79/household/year) is below the highest value for marine turtles reported in the literature (USD 153/household/year WTP of ecotourists for conservation of marine turtles at Mon Repos Beach, Queensland, Australia – Tisdell and Wilson, 2001) and considerably lower than WTP for Asian elephants (USD 1074/household/year – Bandara and Tisdell, 2004), beluga whales, harbour seals and blue whales (USD 212/household/year – Boxall et al., 2012) and orangutans (USD 200/household/year – Zander et al., 2014). In addition, we note that numerous valuation studies have found that non-use values are at least as large as, and often exceed, use values (e.g., Subade and Francisco, 2014; Marre et al., 2015; and Robinson et al., 2022 in the context of coral reefs in the Pacific).

It is worth noting that the geographic scope of wildlife conservation scenarios valued in the literature is generally much smaller than the Asia-Pacific region. The majority of studies assessed local or sub-national conservation programs. This suggests that our WTP estimates for conservation at a continental scale are not out of proportion. Comparing our results to those of Jin et al. (2010), for example, who used the contingent valuation method to estimate mean household WTP for marine turtle conservation in China (USD 16.30), the Philippines (USD 5.87), Vietnam (USD 10.22) and Thailand (USD 18.12), we observe that our estimated household WTP for these countries follows the same relative ordering but with higher absolute values. In addition to differences in study design and the geographic scope of the conservation programs (Jin et al., assess national and multi-country conservation programs), the apparent increase in median household WTP over the 10-year gap between studies may reflect both increasing incomes and the growing strength of public support for wildlife conservation in many Asian societies.

The analysis and results described in this paper are constrained by several limitations, uncertainties and potential biases. Potential future refinements might include the use of alternative payment vehicles to avoid hypothetical bias associated with voluntary donations; experimentation with real money payments to explore the differences and reasons for disparity between hypothetical and actual donations; using quantitative measures of change in turtle populations instead of qualitative descriptions; specifying attributes for specific turtle species to capture differences in preferences across species and level of endangerment; testing for the influence of the survey mode on respondent choice and uncertainty; application of sample weights that reflect the characteristics of the target population in the regression analyses of "in-principle" willingness to donate and WTP; and exploring variation in WTP by demographic and socio-economic variables in order to identify target groups for conservation advocacy and fund-raising efforts.

Marine turtle conservation requires funding, but this has financial and opportunity cost implications for the institutions implementing conservation measures, the sectors that are required to change practices, and the small-scale fishers who currently harvest turtles for their meat, eggs and shells. The cost of conservation raises important issues of equity and compensation, particularly where current income and nutritional sources for coastal communities may be curtailed. Our results indicate that the economic benefits of marine turtle conservation are very high and there is scope for funding compensation, alternative livelihoods, or other incentives to discourage habitat degradation and the unsustainable harvesting of marine turtles. The estimated values provided by this study could potentially be used in cost-benefit analyses of specific conservation programmes to assess the net welfare gains. An important question for financing marine turtle conservation is how to 'capture' public WTP (i.e., turn stated demand for conservation into realised funding)? Actual donations are likely to be limited due to the public good characteristics of biodiversity conservation and lack of trust in institutions to manage funds and deliver conservation outcomes. As such, WTP estimates arguably provide a better measure of welfare derived from biodiversity conservation than of donation behaviour. From responses to additional survey questions on conservation finance, we note that respondents see governments as the insititution with prime responsibility for implementing marine turtle conservation (over international organisations, community groups, NGOs or the private sector); and that the most popular financing structure is voluntary monthly donations for a limited period of time to a fund that is managed by a public institution or an environmental NGO (compulsory payments, such as a tax, were not popular). These results reinforce the case that it is for governments across the region to align their environmental policies and budgets with Asia-Pacific peoples' stated WTP for turtle conservation.

CRediT authorship contribution statement

Luke Brander: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Florian Eppink:** Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Christine Madden Hof:** Conceptualization, Funding acquisition, Supervision. **Joshua Bishop:** Conceptualization, Supervision. **Kimberly Riskas:** Conceptualization, Project administration, Supervision. **Victoria Guisado Goñi:** Data curation, Visualization, Writing – original draft. **Lydia Teh:** Data curation. **Louise Teh:** Data curation.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests.

Luke Brander reports financial support was provided by WWF Australia. Christine Madden Hof reports a relationship with WWF Australia that includes: employment. Joshua Bishop reports a relationship with WWF Australia that includes: employment. Kimberly Riskas reports a relationship with WWF Australia that includes: employment.

Data availability

Data will be made available on request.

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Appendix A. Annex 1. Estimated aggregate WTP for marine turtle conservation in Asia-Pacific

Table A1.1
Aggregated WTP for improvements in marine turtle population trends, from declining to stable, in the Asia-Pacific region (US$/year; 2020 price levels).

Country	Proportion of households willing to pay	Number of households willing to pay	Median WTP/household/year	Total WTP/year
American Samoa	0.89	8777	105.96	930,047
Australia	0.89	9,100,925	84.21	766,428,746
Brunei	0.92	73,112	95.28	6,966,373
Cambodia	0.77	2,838,842	107.82	306,083,607
China	0.80	370,478,750	83.49	30,930,512,361
Cook Islands	0.89	4238	82.03	347,651
Fiji	0.88	163,715	39.94	6,538,305
French Polynesia	0.91	65,781	91.69	6,031,460
Guam	0.91	41,647	99.35	4,137,851
Hong Kong	0.85	2,283,728	71.09	162,348,208
Indonesia	0.76	52,262,149	66.98	3,500,492,636
Japan	0.84	44,511,608	66.65	2,966,916,837
Kiribati	0.87	17,263	109.20	1,885,018
Macau	0.90	198,634	77.79	15,452,337
Malaysia	0.85	5,959,356	70.75	421,620,116
Marshall Islands	0.88	7549	116.69	880,909
Micronesia	0.87	16,682	107.85	1,799,097
Nauru	0.78	1416	111.37	157,705
New Caledonia	0.89	72,671	91.89	6,677,494
New Zealand	0.89	1,582,480	84.95	134,433,230
Niue	0.87	458	108.07	49,481
North Korea	0.70	4,086,197	87.40	357,136,741
Northern Mariana Islands	0.89	15,472	91.13	1,409,961
Palau	0.78	4848	87.98	426,543
Papua New Guinea	0.86	1,452,583	116.62	169,400,720
Philippines	0.79	18,441,367	60.66	1,118,723,258
Samoa	0.88	25,184	110.72	2,788,336
Singapore	0.87	1,547,440	88.21	136,498,025
Solomon Islands	0.85	105,910	117.53	12,447,239
South Korea	0.87	18,527,844	74.76	1,385,175,906
Taiwan	0.85	5,938,458	76.56	454,642,836
Thailand	0.80	15,005,433	82.26	1,234,289,324
Timor-Leste	0.86	194,435	126.96	24,684,984
Tokelau	0.88	230	116.51	26,747
Tonga	0.88	16,403	115.01	1,886,580
Tuvalu	0.84	1646	106.64	175,542
Vanuatu	0.87	55,988	118.01	6,607,294
Vietnam	0.80	21,688,232	73.01	1,583,448,896
Wallis and Futuna	0.83	2346	89.46	209,864
Asia-Pacific region		576,799,798	79.28	45,730,668,262

Appendix B. Annex 2. Summary of reported WTP for species conservation

Table A2.1
Summary of WTP for species conservation (USD/household/year; 2020 price levels).

Type of species	Number of estimates	Mean	Std. Deviation	Minimum	Maximum
Mammal	115	85.95	236.42	0.15	1829.43
Coral	1	84.67		84.67	84.67
Gastropoda	1	83.16		83.16	83.16
Fish	48	68.85	57.04	1.63	176.87
Plant	5	41.01	61.38	0.60	144.08
Branchiopods	1	35.31		35.31	35.31
Bird	80	33.60	38.63	0.28	194.26
Reptile	41	32.41	45.14	0.15	152.68
Invertebrate	4	2.28	0.56	1.72	2.95
Algae	4	2.23	0.54	1.68	2.87
Insect	1	2.14		2.14	2.14
All	301	58.08	151.16	0.15	1829.43
Marine turtles in the Asia-Pacific region (this study)		79.28		39.94	126.96

Appendix C. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecolecon.2024.108148.

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