frontiers | Frontiers in Marine Science

TYPE Original Research
PUBLISHED 12 November 2024
DOI 10.3389/fmars.2024.1459187

Does nature's contributions to people value realization policy in China improve public awareness and preferences for marine biodiversity conservation? A temporal stability analysis

Dandan Liu[1], Jingmei Li[1,2*], Jingzhu Shan[2] and Fangyuan Shi[3]

[1]School of Economics, Ocean University of China, Qingdao, China, [2]Institute of Marine Development, Ocean University of China, Qingdao, China, [3]Weifang Branch, China Merchants Bank, Weifang, China

OPEN ACCESS

EDITED BY
James Scott Maki,
Marquette University, United States

REVIEWED BY
Changlin Ao,
Northeast Agricultural University, China
Antonio J. Díaz-de-León,
Independent researcher,
Ciudad de México, Mexico

*CORRESPONDENCE
Jingmei Li
jingmeili66@ouc.edu.cn

RECEIVED 03 July 2024
ACCEPTED 21 October 2024
PUBLISHED 12 November 2024

CITATION
Liu D, Li J, Shan J and Shi F (2024) Does nature's contributions to people value realization policy in China improve public awareness and preferences for marine biodiversity conservation? A temporal stability analysis.
Front. Mar. Sci. 11:1459187.
doi: 10.3389/fmars.2024.1459187

Management policies are crucial for safeguarding sustained and stable marine biodiversity amidst ongoing pressures such as land use change, pollution, resource overexploitation, invasive alien species and climate change. China established a nature's contributions to people value realization policy (NCPVR) in 2021, aiming to encourage stakeholders to prioritize environmentally beneficial production and consumption choices, thereby stimulating intrinsic public motivation for ecological conservation. Biodiversity conservation is an integral component of the NCPVR policy. A choice experiment method was employed to investigate the changes in public preferences for marine biodiversity conservation in Jiaozhou Bay before and after the enactment of the NCPVR policy (in 2017 and 2023, respectively), aiming to evaluate the effectiveness of the policy on marine biodiversity conservation. The results indicate that two years after the implementation of the NCPVR, the public's overall breadth and depth of awareness regarding marine biodiversity increased. Additionally, public preferences for marine biodiversity conservation increased, expanding from two categories in 2017 (shallow-water swimming organisms and marine plants) to five categories in 2023 (with the addition of seabirds, plankton, and intertidal and benthic organisms). The willingness to pay (WTP) for seabirds, plankton, and intertidal and benthic organisms, as well as shallow-water swimming organisms, increased from 32.21~85.77 CNY/person·year to 98.21~140.49 CNY/person·year. China's NCPVR policy effectively conveyed important information about biodiversity conservation in the short term, enhancing public awareness and preferences for marine biodiversity conservation. The study also revealed that economic incentive policies for NCPVR remain at the conceptual propaganda level and lack operational incentives for biodiversity conservation. It is recommended that the government deepen the design of value realization pathways and market trading arrangements to stimulate the intrinsic motivation of the public for marine biodiversity conservation and ensure the long-term effectiveness of policies.

KEYWORDS

nature's contributions to people value realization (NCPVR), biodiversity surveys, indigenous and local knowledge (ILK) and perception, choice experiment, test-retest, policy evaluation, Jiaozhou Bay, Qingdao

 10.3389/fmars.2024.1459187

1 Introduction

Biodiversity serves as the cornerstone of the global economy and human well-being, providing a rich variety of essential goods for production and livelihoods, a healthy and secure ecological environment, and a unique and exquisite natural landscape and cultural heritage (TEEB, 2011). The ocean covers approximately 71% of the Earth's surface. As a crucial component of the marine biosphere, marine biodiversity constitutes an essential guarantee for human survival and development. Marine organisms provide abundant food, pharmaceuticals, and chemical raw materials for human beings, as well as ecological functions such as coastal protection, waste decomposition, climate regulation, and recreational activities, and harbor enormous ecological, economic, and cultural value (MA, 2005; TEEB, 2010; IPBES, 2019).

China has over 29,300 recorded marine species, constituting approximately 12.2% of the global marine species (SEE, 2023). However, land use change, mechanical change or habitat loss, pollution, resource overexploitation, invasive alien species and climate change have led to a continuous decline in marine biodiversity since the 1990s (Mace et al., 2012; Jaureguiberry et al., 2022). Furthermore, China's marine ecosystems possess evident regional and unique characteristics, with a plethora of endemic and local species highly reliant on pristine coastal habitats (Li, 2019). The sustained pressure from economic growth has markedly heightened the vulnerability of marine ecosystems and biodiversity. Biodiversity exhibits the typical characteristics of a public good and faces pressure from the tragedy of the commons. To mitigate ecosystem degradation and enhance the supply capacity and health level of ecosystems, the Chinese government introduced an economic incentive policy called nature's contributions to people value realization (NCPVR)[1]. "*A guideline on setting up and improving the mechanism to realize the value of nature's contributions to people*" was issued in 2021, and the exploration of NCPVR was included as one of China's biodiversity conservation practices in "*Biodiversity Conservation in China (2021)*" and the "*China National Biodiversity Conservation Strategy and Action Plan (2023-2030)*". NCPVR serves as an important mean for the Chinese government to implement ecological civilization construction[2], aiming to encourage stakeholders to protect the environment and ensure that they obtain conservation benefits, driving economic entities to make production and consumption choices conducive to the most favorable environmental improvements as perceived by policy-makers, and stimulating the intrinsic motivation of the public for ecological conservation.

How environmental management policies stimulate individuals' willingness and behaviors to participate in environmental protection is a widely discussed topic in environmental economics and management. Policies can primarily influence public environmental protection behavior through two pathways: by conveying information to affect public cognition or by providing incentives or constraints on public behavior. Regarding the role of environmental policies in enhancing public environmental awareness, Stern (2000) pointed out that policy orientation is one of the influencing factors of public environmental behavior. Individuals express their support or acceptance of environmental policies, such as endorsing environmental regulations or willingness to pay higher taxes for environmental protection, which further influences the formulation and optimization of public policies. Lehman and Geller (2004) showed that policies can guide the public's perception and views on environmental issues, thereby influencing public environmental behaviors. Steg and Vlek (2009) noted that once environmental knowledge is disseminated in the form of public policies, it reflects the intentions and visions of policy-makers for environmental governance and provides social support and moral obligations to strengthen social norms, further changing the public's environmental preferences and willingness to pay. Rambonilaza and Brahic (2016) noted that environmental policies can enhance public environmental awareness and literacy by facilitating the dissemination of specific environmental knowledge. Wang et al. (2024) believed that environmental policies will jointly affect the public's willingness to pay for environmental protection through the explanatory effect (affecting public environmental cognition) and resource effect (alleviating resource constraints).

In terms of constraining or incentivizing public behavior through policies, Maki et al. (2016) conducted a meta-analysis to explore the effects of monetary incentives (cash) and nonmonetary incentives (such as gifts or coupons) on the duration of environmental behavior. Their results showed that both types of economic incentives, whether monetary or nonmonetary, have small to moderate effects on environmental behavior during and after the intervention period, demonstrating that economic incentives help change and sustain pro-environmental behavior. Chen et al. (2020) investigated the influence of the new environmental protection law on the environmental behavior of the Chinese people, and their results indicated that legislation and regulations can increase the public's sense of responsibility for environmental protection and reduce their expectations of risk and behavior costs, thus encouraging them to engage in pro-environmental behavior.

The choice experiment (CE) is one of the primary methods used in behavioral and experimental economics. It simulates decision-making scenarios for environmental protection in real-life

1 "Nature's contributions to people (NCP; Díaz et al., 2015, 2018; IPBES, 2019; Schröter et al., 2020)" also called "ecological/ecosystem products" in Chinese studies. The objective of the Nature's contributions to people value realization (NCPVR) policy in China is to establish an incentive or regulatory mechanism whereby providers or conservers of nature receive benefits, while users or those responsible for ecological degradation are required to bear the associated costs. NCPVR aims to incentivize or constrain behaviors, thereby ensuring the sustained and stable capacity of ecosystems to deliver goods and services without degradation.

2 "Ecological civilization construction" is an important component of upholding and improving socialism with Chinese characteristics, aiming at to create a society where ecological principles guide policies and practices, fostering a sustainable future while addressing challenges like climate change and urbanization.

situations. By observing respondents' actual choice behaviors and collecting data on respondents' behavior patterns, preferences, and decision-making processes regarding environmental decision scenarios, the CE can provide a scientific basis for the development of effective policies and intervention measures. In recent years, an increasing number of scholars have used the CE to explore respondents' optimal choices in alternative biodiversity conservation scenario sets through utility maximization, revealing participants' preferences or willingness to pay (WTP) for different attributes in decision scenarios. Wallmo and Lew (2012) indicated that respondents were willing to pay $40 to $73 for endangered species recovery in the U.S. Stefanski and Shimshack (2016) assessed the public willingness to pay for marine biodiversity protection in the Gulf of Mexico, with each household's WTP ranging from $35 to $107. Researchers have also been concerned about whether preferences for biodiversity protection will change over time. Schaafsma et al. (2014) used the CE to study the public's protection preferences for nature reserves by conducting two surveys on the same respondents within one year. The results showed significant differences in protection choices and preferences between the two surveys, but WTP remained stable over time. Lew and Wallmo (2017) compared preferences and WTP values for threatened and endangered marine species protection between two identical surveys carried out in 2009 and 2010. Their results showed that public preferences and WTP for endangered species protection remained stable between 2009 and 2010.

While these studies demonstrated the potential for changes in preferences for biodiversity protection over time, they did not explore the underlying reasons for changes in preferences and WTP. Individuals' preferences and willingness to pay for a commodity may change over time due to changes in external information (Czajkowski et al., 2016), especially when facing external uncertainties such as drastic changes in economic conditions or political events or unexpected events. Perni et al. (2020) conducted two contingent valuation (CV) surveys on water quality improvement in the Mar Menor coastal lagoon in Spain in 2010 and 2017. They found that when environmental protection policies are not correctly implemented or fail to achieve their specified goals, the public's preferences and willingness to pay for water quality improvement may change. Hynes et al. (2021) showed that environmental preferences and WTP before and after COVID-19 remained stable. Wunsch et al. (2022) reported changes in public preferences and WTP for coastal protection during the COVID-19 pandemic.

Biodiversity is a common resource, and the effectiveness of biodiversity conservation relies on the public's awareness of the ecosystem services provided by biodiversity, such as maintaining ecosystem productivity and stability, and their cost–benefit evaluations of protective actions. Has China's NCPVR policy effectively conveyed knowledge about the ecological environment and biodiversity protection to the public? Has it generated significant or sufficient incentives to prompt the public to engage in proactive conservation behaviors? What are the factors influencing the public's compliance with biodiversity conservation policies? Choice experiments were employed to explore changes in public preferences and WTP for marine biodiversity conservation after the implementation of the NCPVR policy.

Jiaozhou Bay, located in the eastern coastal region of China, is a typical representative of China's temperate sea areas and boasts rich biodiversity. Moreover, the level of urbanization in this area is relatively high, with numerous channels for information dissemination, making the public more sensitive to environmental issues. Thus, Jiaozhou Bay was selected as the study area, and two surveys were conducted on public preferences for marine biodiversity conservation in 2017 and 2023. The 2017 survey mainly focused on local residents' preferences and willingness to pay (WTP) for biodiversity conservation. After the implementation of NCPVR, the second survey conducted in 2023 to assess the impact of the policy on preferences and WTP. The respondents were randomly selected from among the residents of Jiaozhou Bay to explore the marginal changes in public conservation preferences and WTP for different marine species before and after the proposal of the NCPVR policy. Furthermore, factors affecting the effective implementation of marine biodiversity conservation policies were analyzed. In addition, the time stability test of preferences was completed. The objectives of this study are as follows: first, to evaluate the effectiveness of the NCPVR policy in biodiversity conservation; second, to quantify the marginal changes in public preferences for marine biodiversity conservation before and after the implementation of the policy; and third, to explore the factors affecting the effective implementation of biodiversity conservation policies.

The structure of this article is as follows: Section 2 introduces the methods for choice experiments and preference stability tests; Section 3 presents an overview of marine biodiversity in the study area, describing the experimental design and survey implementation process; and Section 4 shows the results of model estimation, including the willingness to pay (WTP) for various marine biodiversity attributes and the results of a difference test between WTP in the two periods. Section 5 summarizes the research conclusions and provides a discussion. Section 6 provides policy recommendations.

2 Methods

2.1 Choice experiment

The foundation of the choice experiment method lies in the theory of attribute value and random utility theory. Lancaster (1966) proposed the theory of consumer behavior, suggesting that the utility consumers derive from goods originates from various attributes. Thus, the choice experiment method divides the research object into multiple attributes with different levels and combines them into different choice sets. McFadden (1973) stated that random utility theory assumes that individuals choose options that provide maximum utility. The utility U_{ni} of respondent n choosing option i is composed of the observable part V_{ni} and the unobserved random part ε_{ni}:

$$U_{ni} = V_{ni} + \varepsilon_{ni} \tag{1}$$

where V_{ni} depends not only on the attributes of the commodity but also on the socioeconomic attributes of the respondents. Therefore, the utility function can be further expressed as:

$$U_{ni} = V_{ni} + \varepsilon_{ni} = ASC + \sum_k^{Ki} \beta_{ik} X_{nik} + \sum_m \theta_{nm}(ASC \times Z_{nm}) + \varepsilon_{ni} \quad (2)$$

An alternative specific coefficient (ASC) was added to capture respondent heterogeneity in the utility function. *ASC* is assigned the value of 1 when the respondent pays to protect marine species; otherwise, it is assigned 0. β_{ik} is the coefficient of the *kth* marine biodiversity attribute of alternative *i*. X_{nik} is the *kth* marine biodiversity attribute of alternative *i* shown to respondent *n*. θ_{nm} is the vector of coefficients for the interaction between *ASC* and the *mth* socioeconomic characteristic of respondent *n*. Z_{nm} is the *mth* socioeconomic characteristic of respondent *n*. ε_{ni} is the random error term.

To estimate the probability of choosing an alternative *i*, assumptions need to be made about the distribution of the stochastic term ε_{ni}. Different assumptions about ε_{ni} lead to different choice model specifications (Train, 2003). It is commonly assumed that ε_{ni} is independently and identically distributed, following a Gumbel distribution. In this case, estimation can be carried out using the multinomial logit model (MNL). However, the MNL model imposes the independence of irrelevant alternatives (IIA) assumption, which means that "The relative probability of each option being chosen is unaffected by the addition or removal of other alternatives" (Hensher et al., 2005). Furthermore, the MNL model assumes that preferences are uniformly distributed across the entire population, which may lead to potential bias in parameter estimation. When the IIA assumption is violated, more complex statistical models, such as the random parameter logit model (RPL), are employed for estimation. RPL acknowledges the presence of preference heterogeneity and allows parameters in the model to vary across individuals in the population. In this case, the probability of individual *n* choosing alternative *i* is given by:

$$P_{ni} = \int \frac{e^{\beta X_{ni}}}{\sum_k e^{\beta X_{nk}}} f(\beta) d\beta \quad (3)$$

where $f(\beta)$ is a density function, which assumes a continuous distribution similar to the normal distribution in RPL.

The marginal utility estimated by using a probability choice model can be translated into estimates of willingness to pay for changes in attribute levels (Hanley et al., 2005). The marginal willingness to pay for attribute *i* can be calculated as follows:

$$WTP_i = -\frac{\beta_i}{\beta_p} \quad (4)$$

where β_i is the coefficient of the attribute of interest and β_p is the payment attribute.

The social welfare of marine biodiversity conservation can be calculated using compensating surplus (CS):

$$CS = -\frac{1}{\beta_p} \left| ln\sum e^{V^0} - ln\sum e^{V^1} \right| \quad (5)$$

where β_p is the coefficient of the monetary attribute. V^0 and V^1 represent indirect utility functions before and after the conservation choice, respectively.

2.2 Temporal stability test

This study present an examination of the differences in marine biodiversity protection scheme choices and WTP among respondents in the same area at six-year intervals, reflecting the temporal stability of public preferences and WTP before and after policy implementation, as well as the validity of policy implementation. Based on a study by Schaafsma et al. (2014), the following two hypotheses can be tested to compare whether preferences and WTP changed between the two periods:

H1: There are no significant differences in any of the model parameters between the two samples from different periods:

$$\beta_{i,t1} = \beta_{i,t2} \quad (6)$$

H2: There are no significant differences in the marginal willingness to pay for all attributes *i* between the two samples from different periods:

$$WTP_{i,t1} = WTP_{i,t2} \quad (7)$$

The test for H1 is based on the method proposed by Swait and Louviere (1993) and is conducted through likelihood ratio tests:

$$LR = -2[L_{t1+t2} - (L_{t1} + L_{t2})] \quad (8)$$

L_{t1+t2} represents the log likelihood of the pooled data model, while L_{t1} and L_{t2} represent the log likelihoods of the data in two different periods. After obtaining the likelihood ratio statistic, hypothesis testing can be conducted to determine whether the differences between the models are significant. Rejecting the null hypothesis indicates significant differences between the two models, suggesting the absence of temporal stability.

The test for H2 involves analyzing the confidence intervals of WTP in the multinomial logit model and examining the differences in WTP parameter estimates between the two periods to determine whether the mean WTP in the two surveys is equal. Furthermore, following the method proposed by Poe et al. (2005), a test for the differences in the empirical distributions of WTP was conducted.

3 Study area and survey design

3.1 Study area

Jiaozhou Bay is a semienclosed bay located on the southern coast of the Shandong Peninsula in the central Yellow Sea of China (Figure 1). It's located in the warm temperate zone, with significant seasonal changes in water temperature and abundant nutrient content near the coast, providing sufficient nutrients for the growth and reproduction of marine species. The phytoplankton community structure in Jiaozhou Bay is mainly composed of diatoms and dinoflagellates, while benthic algae are represented by Chlorophyta, Phaeophyta, and Rhodophyta. The wetlands of Jiaozhou Bay host additional plant species, such as reeds and *Suaeda salsa*, contributing to a rich diversity of marine plant resources. Jiaozhou Bay is a bait and nursery ground for important economic fish, shrimp, crabs, and

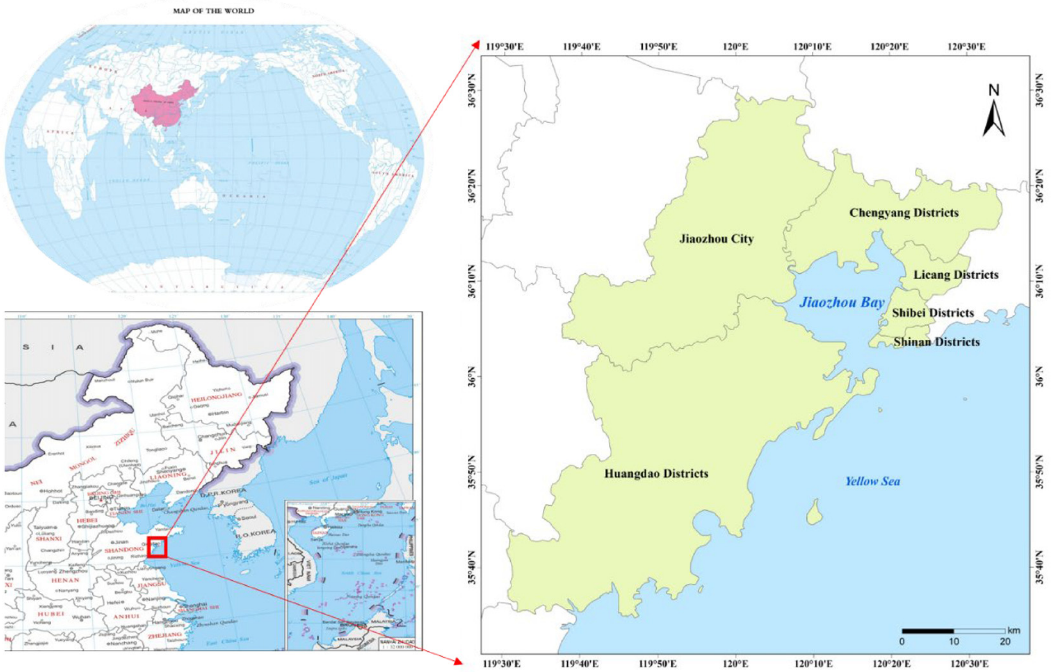

FIGURE 1
The map of the Jiaozhou Bay area. Figure 1 is modified from original figures (Drawing review No: GS(2019)1708, No: GS(2021)5450) downloaded from the website of the Ministry of Natural Resources of the People's Republic of China (http://bzdt.ch.mnr.gov.cn/).

shellfish, such as mantis shrimp, *Portunus trituberculatus*, flounder, black porgy, blue-spotted trevally, and Manila clam. Jiaozhou Bay is also one of the areas in China with the richest diversity of seabirds. There are 157 species of birds from 64 families in 19 orders in the wetlands of Jiaozhou Bay, which are important breeding, migratory, and wintering grounds for rare bird species such as the Chinese crested tern, lesser sand plover, great knot, Eurasian curlew, and black-headed gull. Among the critically endangered bird species listed in the International Union for Conservation of Nature (IUCN) Red List, five species have been identified in the wetlands of Jiaozhou Bay.

Industrial development has exerted pressure on Jiaozhou Bay's marine habitats since the 1950s, leading to habitat loss and pollution that significantly impact bird populations and fish migration. Since the 1980s, the biodiversity of Jiaozhou Bay has sharply decreased, with some rare and endangered species facing extinction. In 1985, more than 200 bird species were surveyed in the Jiaozhou Bay wetlands. However, this number declined by 25% in 2009 (Wang et al., 2016). The number of fish species caught decreased from 109 in the 1980s to 58 in the 1990s, a reduction of 46.3% (Wu, 1999). Net catches during the 1990s were approximately 10% of those in the 1980s, with a notable decline in high-value economic species such as flounders, groupers, sauries, and Japanese tonguesole (Wu and Chai, 1993; Wu, 1999). Benthic and zooplankton populations exhibit significant fluctuations, while dominant phytoplankton species are increasingly homogenized.

In 2012, the local government designated a 203.8 km protection control line and a 370.6 km^2 protection area to address the long-standing problem of the shrinking water area of Jiaozhou Bay due to reclamation (Qingdao Municipal Urban Planning Bureau and Qingdao Municipal Oceanic and Fishery Administration, 2012). With the implementation of China's ecological civilization construction strategy, the local government has accelerated the process of marine ecological protection and has successively carried out environmental improvement and ecological restoration projects such as coastal rehabilitation and restoration, coastal wetland vegetation restoration, hydrodynamic environment remediation, and biotic resource recovery. The ecological environment of Jiaozhou Bay has continued to improve, and its biodiversity has effectively recovered. In 2022, the proportion of the area with excellent water quality in Jiaozhou Bay reached 99% (Qingdao Ecological and Environment Bureau, 2022). A total of 71 species of phytoplankton, 79 species of zooplankton, 97 species of large benthic organisms, 157 species of wetland birds, and 178 species of marine fish have been monitored in Jiaozhou Bay, indicating the gradual recovery of marine biodiversity.

3.2 Survey design

In 2017 and 2023, two surveys were conducted in the urban area of Qingdao, where Jiaozhou Bay is located. A total of 798 valid questionnaire responses were obtained. The respondents were selected using a stratified random sampling method, with local residents from seven districts of Qingdao (Shinan District, Shibei District, Licang District, Laoshan District, Chengyang District, Huangdao District (i.e., West Coast New Area), and Jimo District) being randomly invited to participate in face-to-face surveys. The age and gender ratios were based on Qingdao's Seventh National Census to ensure the representativeness of the sample. However, due to the higher refusal rate or invalid responses from individuals above 50 years old during the survey, the education level of respondents with valid questionnaires tends to be higher and their age is concentrated compared to census data. The survey was conducted by 13 well-trained interviewers. Only individuals aged 18 and above were selected for analysis.

The first survey was conducted in March 2017, aiming to assess the public willingness to pay for the conservation of marine biodiversity in Jiaozhou Bay and to evaluate the value of marine biodiversity conservation. The questionnaire consisted of four parts: the first part provided background information on the biodiversity of Jiaozhou Bay, describing changes in biodiversity since the 1950s; the second part investigated respondents' familiarity with marine biodiversity, satisfaction with the current situation, and the welfare effects of marine biodiversity; and the third part involved the design of choice experiment attributes. The respondents were first briefed on the attributes and levels of biodiversity in Jiaozhou Bay, including five attributes of marine organisms (seabirds, zooplankton, intertidal and benthic organisms, shallow-water swimming organisms, and marine plants) and three attribute levels (improvement, maintenance, and deterioration). The respondents were asked to choose marine biodiversity conservation alternatives based on their conservation preferences and financial capacity; the fourth part was a survey of respondents' socioeconomic characteristics, including gender, age, education, and income. A total of 325 questionnaires were randomly distributed to the public in living areas, supermarkets, and beaches. After excluding invalid and protest payment questionnaires, 275 valid questionnaires were obtained, resulting in a total of 1650 observations for the 2017 survey.

Since 2021, the Chinese government has implemented the NCPVR policy, and the Qingdao municipal government has successively issued supporting documents such as the "*14th Five-Year Plan for Ecological Environment Protection in Qingdao City*," "*Outline of the Beautiful Qingdao Construction Plan (2022-2035)*", "*Outline of Construction Plan for National Ecological Civilization Demonstration Zone in Qingdao City (2021-2030)*," and "*Implementation Plan for Establishing and Improving the Pilot Program for Nature's contributions to people Value Realization*". At the same time, in conjunction with important events such as Wetlands Day, International Day for Biological Diversity, and World Environment Day, Qingdao has conducted diverse public outreach initiatives to enhance awareness and understanding of marine biodiversity conservation efforts. Therefore, a follow-up survey was conducted to assess the impact of the NCPVR policy on public perceptions and behaviors related to marine biodiversity conservation. Additional questions regarding the nature's contributions to people were added to the 2017 questionnaire, including "Have you heard of nature's contributions to people?" "Do you consider Jiaozhou Bay wetlands, biological populations, and birds to be nature's contributions to people?" "Have you heard of the Nature's contributions to people Value Realization Policy?" "Do you think the value realization policy affects your daily behaviors such as avoiding purchasing young fish, reporting illegal reclamation and bird hunting, actively picking up beach litter, etc." In addition, an open-ended question was included at the end of the questionnaire, asking respondents for suggestions on improving the NCPVR policy in China. Other parts of the questionnaire, such as background information, choice experiment attribute design, and socioeconomic characteristics survey questions, remained the same as those in the 2017 version. The survey team distributed 550 questionnaires in the same area from October to December 2023. After excluding incomplete, unqualified, and protest payment questionnaires, 523 valid questionnaires were obtained, resulting in 3138 valid observations for the 2023 survey.

The selection and status description of biodiversity attributes in the two surveys were based on research findings on the biological resources of Jiaozhou Bay by Zhang et al. (2009); Liang et al. (2015); Yuan et al. (2016), and Wu et al. (2017), further combined with Qingdao city's records and the Qingdao Marine Environmental Bulletin to finalize (see Table 1): marine plants and animals, with animals including seabirds, intertidal and benthic organisms, shallow-water swimming organisms, and zooplankton. Based on the classification of biodiversity attribute characteristics by Christie et al. (2006); Eggert and Olsson (2009), and Juutinen et al. (2011), as well as the analysis of the current status and future potential trends

TABLE 1 Attributes and attribute levels.

Attributes	Description	Levels
Marine plants	Vegetation coverage rate and species diversity of reeds, saltworts, seaweed, etc.	improvement
		maintain*
		deteriorate
Seabirds	Species abundance, density, and diversity of seagulls, common teal, red-crowned cranes, etc.	improvement
		maintain
		deteriorate*
Intertidal and benthic organisms	Species abundance, density, and diversity of red Island clams, blue crabs, scallops, abalones, etc.	improvement
		maintain
		deteriorate*
Shallow-water swimming organisms	Species abundance, density, and diversity of flounder, eels, octopus, oysters, shrimp, etc.	improvement
		maintain
		deteriorate*
Plankton	Species abundance, density, and diversity jellyfish, microorganisms, etc.	improvement
		maintain
		deteriorate*
Payment (CNY/person·year)	Payment received by each respondent per year for marine biodiversity conservation	0*,50,100,150,200

*Indicates the current status level of various attributes of biodiversity in Jiaozhou Bay. Attributes define the characteristics being assessed. In this study, five types of marine organisms were used as attributes.

of biodiversity by WWF (2016) and IUCN (2017), three attribute levels, improvement, maintenance, and deterioration, were set to reflect the current and potential future trends of biodiversity in Jiaozhou Bay. The payment attribute described the amount respondents were willing to pay for the conservation of marine biodiversity in Jiaozhou Bay, and its attribute levels were designed based on a presurvey.

Based on the attributes and their current status levels mentioned above, a total of 1215 combination schemes could be generated. Following the experimental design principles established by Huber and Zwerina (1996) and Louviere et al. (2000), 12 choice sets were selected using orthogonal analysis in SAS software. To mitigate significant cognitive burden, these choice sets were randomly combined into two versions of survey questionnaires, each comprising 6 choice sets. Example of the choice sets are illustrated in Table 2. Each choice set comprises three options: two marine biodiversity conservation options (Alternative A and Alternative B), leading to at least one attribute level being maintained or improved, with respondents being required to pay a certain fee accordingly; and an "opt-out" option, representing the scenario where respondents choose to forgo selection or prefer not to take any conservation action, and this option does not require any payments.

4 Results

4.1 Sample characteristics

Table 3 presents the descriptive statistics and statistical hypothesis testing for both the 2017 and 2023 samples. Following Lourenço-Gomes et al. (2020), statistical tests for equality in the means were performed by parametric testing (t-test) and nonparametric testing (chi-square test and Mann–Whitney U test). The t-test did not reject the hypothesis of equal means for the quantitative variables age ($p = 0.155 > 0.05$) and income ($p = 0.703 > 0.05$). Additionally, the Mann–Whitney U test for the ordinal variable education level ($p = 0.1227$) supported the null hypothesis of equal variable distribution between the samples. Furthermore, the Pearson chi-square test indicated that the means of the binary variable gender were equal ($p = 0.025>0.01$). In conclusion, there were no significant differences in socioeconomic variables such as gender, age, education level, or income between the two samples, suggesting that they represent the same population of respondents.

Analysis of the changes in public awareness of marine biodiversity and nature's contributions to people in Jiaozhou Bay revealed that respondents' awareness of biodiversity significantly improved from 2017 to 2023. In 2017, 84.71% of respondents were aware of "biodiversity," while only 24.13% associated it closely with their daily lives. By 2023, awareness of "biodiversity" increased to 93.22%, with 54.76% closely linking it to their daily lives. When queried about the effects of biodiversity loss on their well-being and that of future generations, over 90% of respondents in both surveys acknowledged an impact. However, only 30.17% of respondents perceived a significant impact in 2017, and this figure rose to 72.71% by 2023. These findings suggest an enhanced awareness among respondents in 2023 regarding the significance and welfare implications of biodiversity compared to 2017.

Regarding awareness of NCPVR policies, 73.26% of respondents stated that they were aware of "nature's contributions to people," and 67.58% of respondents agreed that wetland vegetation, biological populations, and birds are nature's contributions to people. A total of 48.72% of respondents were aware of policies concerning NCPVR. When asked whether the NCPVR policy encouraged respondents to take more protective actions toward Jiaozhou Bay's biological resources, 98.17% of respondents believed that the value realization policy changed their production and consumption behaviors, such as preferring ecotourism, avoiding the purchase of fry, reporting the hunting of birds, and participating in beach clean-up activities. This demonstrates that China's NCPVR policy effectively conveys information about ecological environmental protection, promoting an increase in the public's level of biodiversity awareness and willingness to protect it.

TABLE 2 Example of choice sets.

attributes	Alternative A	Alternative B	Opt-out
Marine plants	maintain	deteriorate	deteriorate
Seabirds	maintain	maintain	deteriorate
Intertidal and benthic organisms	maintain	maintain	deteriorate
Shallow-water swimming organisms	improvement	improvement	deteriorate
Plankton	maintain	deteriorate	deteriorate
Payment (CNY/ person·year)	150	50	0
I choose	□	□	□

4.2 Preference for marine biodiversity conservation

Table 4 displays the estimation results of the random parameters logit model. Model estimation was conducted using the maximum likelihood estimation method with Halton sampling in Nlogit 5.0 software, and the estimation results were obtained after 500 iterations. In the random parameter logit model, marine biodiversity attributes were set as random parameters following a normal distribution. The estimation results of the sample model in 2017 showed that marine plants (PLAN) and shallow-water animals (SWIM) were significant at the 1% level, indicating that respondents had a positive preference for the improvement of these two biodiversity types. The respondents showed no significant preference for the protection of seabirds, intertidal and benthic animals, or plankton. There was a significant change in the preference for marine biodiversity conservation in 2023 compared

TABLE 3 Descriptive statistics.

Variable		Coding	2017			2023			Difference of means tests (p-value)
			%	Mean	S.D.	%	Mean	S.D.	
gender	GEN	0=female; 1=male	47.08 52.92	0.529	0.499	48.37 51.63	0.516	0.500	1.986(0.159) Pearson Chi square
age	AGE	1 = 19-29; 2 = 30-39; 3 = 40-49; 4 = 50-59; 5≥60	55.42 23.07 13.65 6.62 1.24	2.752	1.002	56.98 22.18 13.58 5.93 1.34	2.725	0.994	0.024 (0.155) t-test
education	EDU	1= middle school and blow; 2= high school; 3= undergraduate and college; 4=postgraduate and above	6.20 15.72 57.81 20.27	2.921	0.776	4.97 18.15 53.93 22.94	2.948	0.779	0.1227 Mann-Whitney U
income	INC	1 ≤30000 CNY/a; 2 = 30001-80000 CNY/a; 3 = 80001-100000 CNY/a; 4 = 100001-150000 CNY/a; 5 = 150001-200000; 6>200000	32.64 23.55 18.60 10.33 8.26 6.61	2.579	1.547	32.70 22.94 17.78 13.77 7.07 5.74	2.568	1.513	0.011 (0.703) t-test

to 2017. The estimation results of the sample model showed that all five biodiversity attributes were significant at the 1% level, indicating that respondents had a positive attitude toward the conservation of the five types of marine biodiversity, and the preference for conservation was ranked from high to low as follows: shallow-water animals (SWIM), intertidal and benthic animals (BENT), plankton (ZOOP), seabirds (BIRD), and marine plants (PLAN).

There was heterogeneity in the impact of socioeconomic variables on whether respondents chose to protect marine biodiversity between the two periods. The income in both periods had a significantly positive impact on respondents' choices, indicating that people's payment ability determined how much they were willing to pay, which is consistent with theory. The income effect in 2023 decreased compared to that in 2017. The respondents' preferences for marine biodiversity conservation were also influenced by gender and age in the 2017 sample. Females and younger respondents preferred to take action for marine biodiversity conservation. However, age was no longer a factor influencing the public's adoption of actions for the conservation of marine biodiversity in 2023.

4.3 Temporal stability test of conservation preference and willingness to pay

Based on the method of Swait and Louviere (1993), the differences in the model parameters between the two periods (H1) were tested. Table 5 indicates that there were significant differences between the two estimation models. The first two columns in the table provide the log-likelihood (LL) values of the models for the two periods. Based on the LR test statistic, the null hypothesis of equal preference parameters was rejected at the 5% level (Columns 4 and 5), indicating that the underlying preference structure had changed over the six-year interval; this indicates that against the background of the NCPVR policy, the public's preferences for the protection of marine biodiversity had changed.

Table 6 shows the results of the mean marginal WTP and 95% confidence intervals for each attribute in the two periods. In addition to the results of the WTP heterogeneity test, we examined whether the public's WTP for marine biodiversity protection changed before and after the proposal of the NCPVR mechanism. Krinsky–Robb simulation was used to calculate the relevant marginal WTP and 95% confidence intervals (Krinsky and Robb, 1986), with 500 iterations. The transfer error shows the absolute and relative differences in the mean WTP between the two periods. The marginal WTP (WTP) for marine biodiversity conservation attributes varied significantly between 2017 and 2023, with relative differences ranging from -46% to 205%. Compared to 2017, the annual per capita WTP for marine plants decreased, while the WTP for other attributes increased significantly, ranging from 64% to 205%. The ranking of WTP for each attribute shifted. In 2023, respondents showed the highest WTP for shallow-water swimming animals (140.49 CNY/person·year), followed by intertidal and benthic animals (108.95 CNY/person·year). The WTP for marine plants declined to 85.76 CNY/person·year from its 2017 level; this may have been due to the continuous restoration of marine wetland vegetation in Jiaozhou Bay in recent years, with significant progress in restoration, leading to a relative decrease in public preference for the protection of marine vegetation compared to other attributes.

Based on the method proposed by Poe et al. (2005), the significant difference in the empirical distribution of individual

TABLE 4 Random Parameter Logit Models results.

	2017 (test)		2023 (retest)	
	Coefficient	St. Error	Coefficient	St. Error
random parameters				
PLAN	0.394***	0.078	0.307***	0.045
BIRD	0.081	0.100	0.351***	0.051
BENT	0.115	0.073	0.390***	0.071
SWIM	0.215***	0.070	0.503***	0.056
ZOOP	0.121	0.082	0.376***	0.048
non-random parameters				
PAYMENT	-0.003***	0.001	-0.004***	0.001
ASC	2.639***	0.923	3.064***	0.886
ASC*GEN	-0.584***	0.324	-1.370***	0.297
ASC*AGE	-0.501***	0.173	-0.107	0.150
ASC*EDU	-0.056	0.210	-0.178	0.198
ASC*INC	0.501***	0.134	0.228**	0.099
Standard deviations				
PLAN	0.744***	0.095	0.410***	0.077
BIRD	0.937***	0.115	0.397***	0.087
BENT	0.531***	0.113	0.832***	0.096
SWIM	0.426***	0.108	0.566***	0.084
ZOOP	0.424***	0.121	0.362***	0.087
Model statistics				
No. observations	1452		3138	
Log-likelihood	-1595.185		-2238.916	
McFadden Pseudo-R^2	0.248		0.351	
AIC/n	1.675		1.437	

*** indicate significant at 1%; ** indicate significant at 5% respectively. SWIM =shallow-water animals, BENT =intertidal and benthic animals, ZOOP =plankton, BIRD =seabirds, PLAN =marine plants.

WTP between the two periods was examined. The degree of overlap of WTP confidence intervals was used to reflect the differences in the Poe test. A large overlap indicates no significant difference in the WTP between the two periods. The Poe test can be used to examine the differences in marginal WTP distributions. The Poe test results were all less than 0.9, indicating that the overlap of the WTP distributions for each attribute between the two periods was less than 90%, and there was a significant difference in the WTP distributions between the two periods.

The compensation surplus for the two periods was calculated to reflect the changes in social welfare for the protection of marine biodiversity before and after the implementation of the NCPVR policy. Based on the model estimation results in Table 4 and Formula 5, the annual per capita compensation surpluses for the five representative attribute improvement schemes for marine biodiversity in Jiaozhou Bay in the two periods were 323.06 CNY and 541.69 CNY, respectively; this indicates that after the implementation of the NCPVR policy, the public was willing to pay more money for the protection of marine biodiversity, and there was an increase in public awareness and intrinsic motivation for conservation. The resident populations of Qingdao in 2017 and 2022 were 9.4998 million and 10.3421 million, respectively (Qingdao Municipal Statistics Bureau, 2018; Qingdao Ecological and Environment Bureau, 2022). If the marine biodiversity of Jiaozhou Bay could have been improved by one level, the added social welfare would have been approximately 3.069 billion CNY and 5.602 billion CNY, respectively.

5 Conclusion and discussion

Using policies to guide the public, enhance their awareness of marine biodiversity conservation, and motivate them to engage in conservation behaviors is an important step for protecting marine biodiversity. Public preferences for marine biodiversity conservation before and after the implementation of the NCPVR policy (in 2017 and 2023) were investigated to test the effectiveness of the NCPVR policy in enhancing public awareness of marine biodiversity and guiding behavioral changes toward conservation. The results show that after the implementation of the NCPVR policy, (1) the public's awareness of marine biodiversity and conservation consciousness improved. The proportion of respondents who identified biodiversity as closely related to their lives and believed that the loss of marine biodiversity would seriously affect their welfare more than doubled. (2) Analysis of preference structure and WTP revealed that the number of public preferences for marine biodiversity conservation increased from two (marine plants and shallow-water swimming animals) to five (marine plants, marine plankton, intertidal and benthic organisms, shallow-water swimming animals, and seabirds). The marginal willingness to pay for seabirds, intertidal and benthic organisms, marine plankton, and shallow-water animals increased to varying degrees, with increases ranging from 64% to 205%, reflecting the public's willingness to take more proactive actions to protect marine biodiversity.

TABLE 5 Swait and Louviere test results for hypothesis 1.

LL (2017)	LL (2023)	LL (2017&2023)	LR-test (df=16)	$H_0^a: \beta_i = \beta_j$ rejcted?
-1595.19	-2238.92	-3500.70	666.81	Yes

$\chi^2_{16}(p = 0.05) = 26.30$.

TABLE 6 Marginal WTP (chinese yuan) based on random parameter logit model results.

Attribute	2017 Mean (95% Confidence Interval)	2023 Mean (95% Confidence Interval)	Transfer error Absolute difference (relative difference)	Poe test for difference (α)
PLAN	157.36* (-5.80, 320.51)	85.76*** (49.64, 121.89)	71.60 (-46%)	0.63
BIRD	32.21 (-96.36, 160.78)	98.21*** (55.02, 141.40)	66.00 (205%)	0.47
BENT	45.82 (-37.72, 129.37)	108.95*** (49.93, 167.96)	63.13 (138%)	0.35
SWIM	85.77 (-25.22, 196.76)	140.49*** (93.91, 187.07)	54.72 (64%)	0.30
ZOOP	48.23 (-30.37, 126.83)	105.01*** (59.34, 150.68)	56.78 (118%)	0.21

*** indicate significant at 1%; * indicate significant at 10% respectively. Transfer error were generated based on the (Schaafsma et al., 2014), relative difference = $(WTP_{2023}-WTP_{2017})/WTP_{2017}$. Abbreviations as in Table 4.

Previous studies have shown that policies can influence public awareness through information dissemination, thereby affecting public preferences for environmental protection (Wang et al., 2024). Rambonilaza and Brahic (2016) noted that when people receive information about ecological changes, only those who are familiar with the concept of biodiversity, are aware of the issues involved, and regularly use biological resources tend to assign greater value to biodiversity. In other words, as public awareness of marine biodiversity increases, individuals exhibit heightened sensitivity to survey questions, placing greater emphasis on the conservation of marine biodiversity and resulting in greater WTP. This perspective aligns to a certain extent with the findings of this research. Moreover, the respondents were more willing to pay for marine organisms with which they were more familiar, such as economic species such as fish, shrimp, crabs, and shellfish, which are shallow-water swimming organisms and intertidal and benthic organisms. This study demonstrates the long-term instability of preferences and highlights the role of policy institutions in preference changes, which is consistent with the findings of Perni et al. (2020).

>The survey results on the public's willingness to protect marine biodiversity in Jiaozhou Bay also revealed similar trends. Compared to 2017, there was more than double the number of respondents who recognized the relevance of biodiversity to daily life and those who believed that the loss of biodiversity severely affected welfare in 2023. Nearly all respondents believed that the NCPVR policy encouraged them to adopt more environmentally friendly production and consumption behaviors.

When asked about recommendations for China's NCPVR policy refinement, some respondents suggested that the policy should not be limited to slogan promotion. The government is expected to provide more specific arrangements for value realization, including providing cash or gift rewards to biodiversity protectors, clarifying natural resource property rights to make the perpetrators pay for environmental damage costs, and allowing private capital to restore wetlands, such as by building privately operated parks. Although the NCPVR policy conveys information about the importance and value of biodiversity conservation, the key issue for future policy optimization is how to design effective paths and institutional guarantees for value realization to encourage the public's long-term sustainable marine biodiversity protection behavior.

Stated preference methods were employed to investigate the public's willingness to pay for marine biodiversity conservation, thereby revealing the value of marine biodiversity and serving as a basis for policy evaluation and design. However, over 50 valuation methods have been developed globally in these days, based on various disciplines and knowledge systems, and applicable for assessing the value of natural elements (IPBES, 2019, 2022a, b). For instance, stated preference valuation directly asks individuals to express their values; revealed preference valuation determines how people value nature by observing their behaviors and practices; and composite valuation aggregates various types of value assessed using different information sources. Each method relies on distinct data sources, varying levels and forms of social participation, and identifies different value types, while possessing specific technical and skill requirements and limitations. Therefore, future research may utilize alternative methods or a combination of multiple valuation approaches to assess different stakeholders' valuations of marine biodiversity, providing a more comprehensive and scientifically robust theoretical foundation for the design of marine biodiversity conservation policies.

Additionally, Jiaozhou Bay in Qingdao was chosen as the study area, with the survey sample primarily consisting of individuals with high educational backgrounds. Future research should expand the geographical scope and demographic characteristics of the respondents to obtain a more comprehensive assessment.

6 Policy implications

Biodiversity is essential for ecological security and human well-being, forming the foundation of economic and social development. Protecting biodiversity is a crucial prerequisite for achieving sustainable development. Currently, the world is facing severe challenges, such as accelerated biodiversity loss and ecosystem degradation. To achieve the harmonious development of economic growth, social progress, and the ecological environment, governments are responsible for implementing policies and measures to protect and maintain biodiversity. Nature's contributions to people value realization policy in China has created a favorable atmosphere for various stakeholders to participate in biodiversity protection, enhancing the public's ideological and action awareness of protecting marine biodiversity. In the future, decision-makers should continue to enhance the dissemination of information on the value of marine biodiversity and related policy pathways and enhance the public's understanding of the relationship between biodiversity value realization and well-being improvement, thereby stimulating the public's intrinsic motivation to protect marine biodiversity and providing actionable conservation plans. The specific policy implications are as follows:

(1) Promote widespread education on marine biodiversity to shift values from short-term, individual material interests to long-term sustainable perspectives. Recognizing the interdependence of humans and nature is essential, as worldviews and knowledge systems shape attitudes and behaviors toward the environment (Parks and Guay, 2009; Manfredo et al., 2016; Yang et al., 2022). Expanding the dissemination of information about marine biodiversity, especially concerning lesser-known organisms like plankton, marine plants, and endangered species, is crucial. Highlighting their ecological functions, contributions to human welfare, and conservation status will enhance public understanding. Large-scale citizen science initiatives in coastal areas, parks, and schools can significantly improve awareness of biodiversity's importance for daily life, economic development, and ecological balance.

(2) Continue to assess the value of marine biodiversity using a combination of valuation methods to evaluate diverse value types, balancing short-term economic benefits with long-term ecological and social values. Scientific valuation outcomes can enhance public awareness of marine biodiversity's significance and provide a robust foundation for decision-makers, fostering a win-win scenario for economic growth and environmental protection. Over 50 valuation methods from various disciplines are available to assess nature's value, each with distinct data sources, levels of social participation, and technical requirements (Haab and Mcconnell, 2002; Champ et al., 2017; IPBES, 2022b). Future efforts should focus on strengthening the capacity for comprehensive assessments, gathering baseline data, identifying stakeholders, and establishing systematic evaluation processes. Evaluating the relevance, robustness, and feasibility of different methods is essential (Rakotonarivo et al., 2016; Bishop and Boyle, 2017; IPBES, 2022a, b). Providing scientifically comprehensive biodiversity valuation results will enhance the quality and legitimacy of information to support informed decision-making and guide conservation policy design.

(3) Integrate political, economic, and social elements to establish mechanisms that incentivize marine biodiversity protectors while requiring payment from demanders or destroyers, thereby motivating or constraining behaviors for the long-term sustainability of marine biodiversity conservation. Current economic and political decisions are often criticized for prioritizing narrow market values at the expense of non-market values (Lathuillière et al., 2017; IPBES, 2022a, b). Policies aimed at realizing values of NCP must raise public awareness of the non-market value of natural resources and utilize a combination of government and market tools to promote these values (Gómez-Baggethun and Martín-López, 2015; Albaladejo-García et al., 2023; Pascual et al., 2023). This approach is essential to ensure that ecosystems maintain their capacity to provide services and products sustainably. The efficacy of NCPVR policies in enhancing public awareness of marine biodiversity conservation has been demonstrated. Future biodiversity conservation policies should be developed based on a comprehensive assessment of both market and non-market values, integrating economic incentives, rights, and legal frameworks with public preferences and values (Díaz et al., 2015; IPBES, 2022a, b). Furthermore, embedding valuation into various stages of the decision-making process will facilitate policy reforms that effectively address the global biodiversity crisis.

Data availability statement

The datasets presented in this article are not readily available because the data that has been used is confidential. Requests to access the datasets should be directed to JL, jingmeili66@ouc.edu.cn.

Author contributions

DL: Formal analysis, Investigation, Software, Writing – original draft, Writing – review & editing, Methodology. JL: Conceptualization, Funding acquisition, Supervision, Writing – review & editing, Methodology, Project administration. JS: Funding acquisition, Investigation, Software, Writing – review & editing. FS: Investigation, Software, Writing – original draft.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. The research is funded by Major Project of the National Social Science Foundation of China (No. 16ZDA049), MOE (Ministry of Education in China) Youth Foundation Project of Humanities and Social Sciences (23YJCZH031), Shandong Postdoctoral Innovation Foundation (SDCX-RS-202203016), China Postdoctoral Science Foundation (2022M713003).

Conflict of interest

Author FS was employed by Weifang Branch, China Merchants Bank.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Albaladejo-García, J. A., Alcon, F., Martínez-Carrasco, F., and Martínez-Paz, J. M. (2023). Understanding socio-spatial perceptions and Badlands ecosystem services valuation. Is there any welfare in soil erosion? *Land Use Policy* 128, 106607. doi: 10.1016/j.landusepol.2023.106607

Bishop, R. C., and Boyle, K. J. (2017). "Reliability and validity in nonmarket valuation," in *A primer on nonmarket valuation. The economics of non-market goods and resources*, vol 13. Eds. P. Champ, K. Boyle and T. Brown (Dordrecht: Springer). doi: 10.1007/978-94-007-7104-8_12

Champ, P. A., Boyle, K. J., and Brown, T. C. (2017). *A primer on nonmarket valuation* (Netherlands: Springer). doi: 10.1007/978-94-007-7104-8

Chen, J., Huang, J., Huang, X., Sun, S., Hao, Y., and Wu, H. (2020). How does new environmental law affect public environmental protection activities in China? Evidence from structural equation model analysis on legal cognition. *Sci. Total Environ.* 714, 136558. doi: 10.1016/j.scitotenv.2020.136558

Christie, M., Hanley, N., Warren, J., Murphy, K., Wright, R., and Hyde, T. (2006). Valuing the diversity of biodiversity. *Ecol. Econ.* 58, 304–317. doi: 10.1016/j.ecolecon.2005.07.034

Czajkowski, M., Bartczak, A., Budziński, W., Giergiczny, M., and Hanley, N. (2016). Preference and WTP stability for public forest management. *For. Policy Econ.* 71, 11–22. doi: 10.1016/j.forpol.2016.06.027

Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., et al. (2015). The IPBES Conceptual Framework — connecting nature and people. *Curr. Opin. Environ. Sustain.* 14, 1–16. doi: 10.1016/j.cosust.2014.11.002

Díaz, S., Pascual, U., Stenseke, M., Martín-López, B., Watson, R. T., Molnár, Z., et al. (2018). Assessing nature's contributions to people. *Science* 359, 270–272. doi: 10.1126/science.aap8826

Eggert, H., and Olsson, B. (2009). Valuing multi-attribute marine water quality. *Mar. Policy* 33, 201–206. doi: 10.1016/j.marpol.2008.05.011

Gómez-Baggethun, E., and Martín-López, B. (2015). "Ecological economics perspectives on ecosystem services valuation," in *Handbook of Ecological Economics*. Eds. J. Martinez-Alier and R. Muradian (Cheltenham: Edward Elgar Publishing), 260–282. doi: 10.4337/9781783471416.00015

Haab, T. C., and Mcconnell, K. E. (2002). *Valuing environmental and natural resources: the econometrics of non-market valuation* (Cheltenham: Edward Elgar Publishing). doi: 10.4337/9781843765431

Hanley, N., Adamowicz, W., and Wright, R. E. (2005). Price vector effects in choice experiments: an empirical test. *Res. Energy Econ.* 27, 227–234. doi: 10.1016/j.reseneeco.2004.11.001

Hensher, D. A., Rose, J. M., and Greene, W. H. (2005). *Applied choice analysis:A primer. 1st* (Cambridge: Cambridge University Press). Available at: https://www.cambridge.org/bs/titles/applied-choice-analysis-primer.

Huber, J., and Zwerina, K. (1996). The importance of utility balance in efficient choice designs. *J. Market. Res.* 33, 307–317. doi: 10.1177/002224379603300305

Hynes, S., Armstrong, C. W., Xuan, B. B., Ankamah-Yeboah, I., Simpson, K., Tinch, R., et al. (2021). Have environmental preferences and willingness to pay remained stable before and during the global Covid-19 shock? *Ecol. Econ.* 189, 107142. doi: 10.1016/j.ecolecon.2021.107142

IPBES (2019). *Global assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Eds. E. S. Brondízio, J. Settele, S. Díaz and H. T. Ngo (Bonn, Germany: IPBES secretariat). doi: 10.5281/zenodo.3831673

IPBES (2022a). Summary for Policymakers of the Methodological Assessment Report on the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Eds. Pascual, U., Balvanera, P., Christie, M., Baptiste, B., González-Jiménez, D., Anderson, C. B., Athayde, S., Barton, D. N., Chaplin-Kramer, R., Jacobs, S., Kelemen, E., Kumar, R., Lazos, E., Martin, A., Mwampamba, T. H., Nakangu, B., O'Farrell, P., Raymond, C. M., Subramanian, S. M., Termansen, M., and Van Noordwijk, M. (Bonn, Germany: IPBES secretariat). doi: 10.5281/zenodo.6522392

IPBES (2022b). Methodological Assessment Report on the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Eds. Balvanera, P., Pascual, U., Christie, M., Baptiste, B., and González-Jiménez, D. (Bonn, Germany: IPBES secretariat). doi: 10.5281/zenodo.6522522

IUCN (2017). *Annual Report 2016* (Brussels, Belgium: IUCN European Regional Office). Available at: https://portals.iucn.org/library/sites/library/files/documents/2017-023.pdf.

Jaureguiberry, P., Titeux, N., Wiemers, M., Bowler, D., Luca Coscieme, L., Golden, A., et al. (2022). The direct drivers of recent global anthropogenic biodiversity loss. *Sci. Adv.* 8, eabm9982. doi: 10.1126/sciadv.abm9982

Juutinen, A., Mitani, Y., Mäntymaa, E., Shoji, Y., Siikamäki, P., and Svento, R. (2011). Combining ecological and recreational aspects in national park management: A choice experiment application. *Ecol. Econ.* 70, 1231–1239. doi: 10.1016/j.ecolecon.2011.02.006

Krinsky, I., and Robb, A. L. (1986). On approximating the statistical properties of elasticities. *Rev. econ. Stat* 68, 715–719. doi: 10.2307/1924536

Lancaster, K. (1966). A new approach to consumer theory. *J. polit. econ.* 74, 132–157. doi: 10.1086/259131

Lathuillière, M. J., Miranda, E. J., Bulle, C., Couto, E. G., and Johnson, M. S. (2017). Land occupation and transformation impacts of soybean production in Southern Amazonia, Brazil. *J. Cleaner Product.* 149, 680–689. doi: 10.1016/j.jclepro.2017.02.120

Lehman, P. K., and Geller, E. S. (2004). Behavior analysis and environmental protection: accomplishments and potential for more. *Behav. Soc. Issues* 13, 13–33. doi: 10.5210/bsi.v13i1.33

Lew, D. K., and Wallmo, K. (2017). Temporal stability of stated preferences for endangered species protection from choice experiments. *Ecol. Econ.* 131, 87–97. doi: 10.1016/j.ecolecon.2016.08.009

Li, H. (2019). Progress in marine biodiversity conservation in China. *World Environ.* 178, 16–18. doi: 10.1016/j.ese.2020.100025

Liang, S., Pearson, S., Wu, W., Ma, Y., Qiao, L., Wang, X. H., et al. (2015). Research and integrated coastal zone management in rapidly developing estuarine harbours: A review to inform sustainment of functions in Jiaozhou Bay, China. *Ocean Coast. Manage.* 116, 470–477. doi: 10.1016/j.ocecoaman.2015.09.014

Lourenço-Gomes, L., Pinto, L. M. C., Rebelo, J., and Gonçalves, T. (2020). Temporal stability of discrete choice values for preserving a cultural landscape: The Alto Douro Wine Region. *J. Cult. Herit.* 45, 327–333. doi: 10.1016/j.culher.2020.04.018

Louviere, J. J., Hensher, D. A., and Swait, J. D. (2000). *Stated choice methods: analysis and applications* (Cambridge: Cambridge university press). doi: 10.1017/CBO9780511753831

MA (2005). *Ecosystems and Human Well-being: Biodiversity Synthesis* (Washington, DC: World Resources Institute). Available at: https://www.millenniumassessment.org/documents/document.354.aspx.pdf.

Mace, G., Norris, K., and Fitter, A. (2012). Biodiversity and ecosystem services: a multilayered relationship. *Trends Ecol. Evol.* 27, 19–26. doi: 10.1016/j.tree.2011.08.006

Maki, A., Burns, R. J., Ha, L., and Rothman, A. J. (2016). Paying people to protect the environment: A meta-analysis of financial incentive interventions to promote pro-environmental behaviors. *J. Environ. Psychol.* 47, 242–255. doi: 10.1016/j.jenvp.2016.07.006

Manfredo, M. J., Teel, T. L., and Dietsch, A. M. (2016). Implications of human value shift and persistence for biodiversity conservation. *Conserv. Biol.* 30, 287–296. doi: 10.1111/cobi.12619

McFadden, D. (1973). *Conditional logit analysis of qualitative choice behavior* (UC Berkeley: Institute of Urban and Regional Development). Available at: https://escholarship.org/uc/item/61s3q2xr.

Parks, L., and Guay, R. P. (2009). Personality, values, and motivation. *Pers. Individ. Dif.* 47, 675–684. doi: 10.1016/j.paid.2009.06.002

Pascual, U., Balvanera, P., Anderson, C. B., Chaplin-Kramer, R., Christie, M., González-Jiménez, D., et al. (2023). Diverse values of nature for sustainability. *Nature* 620, 813–823. doi: 10.1038/s41586-023-06406-9

Perni, A., Barreiro-Hurle, J., and Martinez-Paz, J. M. (2020). When policy implementation failures affect public preferences for environmental goods: Implications for economic analysis in the European water policy. *Ecol. Econ.* 169, 106523. doi: 10.1016/j.ecolecon.2019.106523

Poe, G. L., Giraud, K. L., and Loomis, J. B. (2005). Computational methods for measuring the difference of empirical distributions. *Am. J. Agric. Econ.* 87, 353–365. doi: 10.1111/j.1467-8276.2005.00727.x

Qingdao Ecological and Environment Bureau (2022). *Statistical Bulletin on National Economic and Social Development of Qingdao in 2022* (Qingdao: Qingdao Ecological and Environment Bureau). Available at: http://www.qingdao.gov.cn/zwgk/xxgk/fgw/ywfl/jjfz/202304/t20230420_7153787.shtml.

Qingdao Municipal Statistics Bureau (2018). *Statistical Bulletin on National Economic and Social Development of Qingdao in 2017* (Qingdao: Qingdao Municipal

Statistics Bureau). Available at: http://qdtj.qingdao.gov.cn/tongjisj/tjsj_tjgb/202112/t20211221_4101339.shtml.

Qingdao Municipal Urban Planning Bureau and Qingdao Municipal Oceanic and Fishery Administration (2012). *Draft Plan for Delimiting the Protection Control Line and Shoreline Management Around Jiaozhou Bay* (Qingdao: Qingdao Municipal Urban Planning Bureau, Qingdao Municipal Oceanic and Fishery Administration).

Rakotonarivo, O. S., Schaafsma, M., and Hockley, N. (2016). A systematic review of the reliability and validity of discrete choice experiments in valuing non-market environmental goods. *J. Environ. Manage.* 183, 98–109. doi: 10.1016/j.jenvman.2016.08.032

Rambonilaza, T., and Brahic, E. (2016). Non-market values of forest biodiversity and the impact of informing the general public: Insights from generalized multinomial logit estimations. *Environ. Sci. Policy* 64, 93–100. doi: 10.1016/j.envsci.2016.06.008

Schaafsma, M., Brouwer, R., Liekens, I., and De Nocker, L. (2014). Temporal stability of preferences and willingness to pay for natural areas in choice experiments: A test–retest. *Res. Energy Econ.* 38, 243–260. doi: 10.1016/j.reseneeco.2014.09.001

Schröter, M., Başak, E., Christie, M., Church, A., Keune, H., Osipova, E., et al. (2020). Indicators for relational values of nature's contributions to good quality of life: the IPBES approach for Europe and Central Asia. *Ecosyst. People* 16, 50–69. doi: 10.1080/26395916.2019.1703039

SEE (2023). *Report on the Identification of Key Marine Biodiversity Areas in China* (Beijing: Society of Entrepreneurs and Ecology Foundation).

Stefanski, S. F., and Shimshack, J. P. (2016). Valuing marine biodiversity in the gulf of Mexico: evidence from the proposed boundary expansion of the flower garden banks national marine sanctuary. *Mar. Res. Econ.* 31, 211–232. doi: 10.1086/685109

Steg, L., and Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *J. Environ. Psychol.* 29, 309–317. doi: 10.1016/j.jenvp.2008.10.004

Stern, P. C. (2000). New environmental theories: toward a coherent theory of environmentally significant behavior. *J. Soc. Issues* 56, 407–424. doi: 10.1111/0022-4537.00175

Swait, J., and Louviere, J. (1993). The role of the scale parameter in the estimation and comparison of multinomial logit models. *J. Market. Res.* 30, 305–314. doi: 10.1177/002224379303000303

TEEB (2010). *The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations*. Ed. P. Kumar (London and Washington: Earthscan). Available at: https://www.teebweb.org/wp-content/uploads/Study%20and%20Reports/Reports/Ecological%20and%20Economic%20Foundations/TEEB%20Ecological%20and%20Economic%20Foundations%20report/TEEB%20Foundations.pdf.

TEEB (2011). *The Economics of Ecosystems and Biodiversity in National and International Policy Making* (London and Washington: Earthscan). Available at: https://www.teebweb.org/wp-content/uploads/Study%20and%20Reports/Reports/National%20and%20International%20Policy%20Making/Executive%20Summary/National%20Executive%20Summary_%20English.pdf.

Train, K. E. (2003). *Discrete choice methods with simulation* (Cambridge: Cambridge University Press). doi: 10.1017/CBO9780511805271

Wallmo, K., and Lew, D. K. (2012). Public willingness to pay for recovering and downlisting threatened and endangered marine species. *Conserv. Biol.* 26, 830–839. doi: 10.1111/j.1523-1739.2012.01899.x

Wang, B. Z., Lu, Z. X., and Zhang, L. (2016). Current status, problems and conservation strategies for Jiaozhou Bay wetland in Qingdao of Shandong. *Wetland Sci. Manage.* 12, 24–26. Available at: https://oversea.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFD&dbname=CJFDLAST2016&filename=LKGL201602010&uniplatform=OVERSEA&v=0MKsEJkLSNxi1zjBzS6eQi_XJQMkXcSrN5Cj2hZIFOdeA0W3mcrRQDjma0BlfGhz.

Wang, S., Wang, G., and Xiao, Y. (2024). How environmental policies affect personal willingness to pay for environmental protection: an investigation of interpretative and resource effects. *Environ. Dev. Sustain.* 26, 1591–1613. doi: 10.1007/s10668-022-02775-9

Wu, Y. (1999). Effect of the development of the coastal zone on the organism resources in Jiaozhou Bay. *Mar. Environ. Sci.* 2, 38–42. Available at: https://oversea.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFD&dbname=CJFD9899&filename=HYHJ199902007&uniplatform=OVERSEA&v=bRdwJxCwT_9-MjTswoQkLTRkrpLNJilX5EhaDTNJ0NzwBmp5DExB4atMGPzpq6L_.

Wu, Y., and Chai, W. (1993). Utilization of aquatic economic animal resources in Jiaozhou bay. *Mar. Sci.* 5, 21–23. Available at: https://saishi.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFD&dbname=CJFD9093&filename=HYKX199305008&uniplatform=OVERSEA&v=HTlc-0xhtm8HqK_uQ5E0Tmgd307mJ78l5hr05bOxK1hX6yze1kVvI0E8zqD6hGrg.

Wu, W., Yan, S., Feng, R., Song, D., and Chen, X. (2017). Development of an environmental performance indicator framework to evaluate management effectiveness for Jiaozhou Bay Coastal Wetland Special Marine Protected Area, Qingdao, China. *Ocean Coast. Manage.* 142, 71–89. doi: 10.1016/j.ocecoaman.2017.03.021

Wunsch, A., Meyerhoff, J., and Rehdanz, K. (2022). A test–retest analysis of stated preferences in uncertain times. *Econ. Anal. Policy* 73, 725–736. doi: 10.1016/j.eap.2021.12.021

WWF (2016). *Living Planet Report 2016:Risk and resilience in a new era* (Gland, Switzerland: WWF International). Available at: https://c402277.ssl.cf1.rackcdn.com/publications/964/files/original/lpr_living_planet_report_2016.pdf?1477582118&_ga=1.148678772.2122160181.1464121326.

Yang, J., Su, K., Zhou, Z., Huang, Y., Hou, Y., and Wen, Y. (2022). The impact of tourist cognition on willing to pay for rare species conservation: Base on the questionnaire survey in protected areas of the Qinling region in China. *Global Ecol. Conserv.* 33, e01952. doi: 10.1016/j.gecco.2021.e01952

Yuan, Y., Song, D., Wu, W., Liang, S., Wang, Y., and Ren, Z. (2016). The impact of anthropogenic activities on marine environment in Jiaozhou Bay, Qingdao, China: A review and a case study. *Reg. Stud. Mar. Sci.* 8, 287–296. doi: 10.1016/j.rsma.2016.01.004

Zhang, X., Zhang, Z., Xu, Z., and Zheng, W. (2009). Biodiversity characteristics of coastal wetlands in Jiaozhou bay. *Sci. Technol. Rep.* 27, 36–41. Available at: https://oversea.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFD&dbname=CJFD2009&filename=KJDB200913018&uniplatform=OVERSEA&v=3URzGRe6N9Sg6e3exuC4Gp2o8yyfD4cqQruxcloVJl5JgFKHLPzX39gdN635LFxf.