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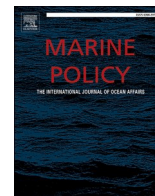
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Public preferences for policies promoting the conservation of a universally threatened species (*Anguilla spp.*): Insights from a choice experiment in Japan

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ABSTRACT

The population of the Northern temperate eel species (*Anguilla spp.*) has undergone a significant decline, resulting in their classification as Endangered (American eel *Anguilla rostrata* and Japanese eel *Anguilla japonica*) or Critically Endangered (European eel *Anguilla anguilla*) by the IUCN. The growing global demand for Japanese cuisine and processed eel products could potentially exacerbate the vulnerability of these species. This research examines the acceptability of conservation policies among Japanese consumers. A discrete choice experiment was employed to investigate the social acceptance of target levels for national eel consumption reduction and to examine the trade-offs made by individuals between various policy instruments (e.g., combat against illegal trade, research on artificial reproduction, shift to substitute species, public awareness campaigns, eco-labelling) and the costs that they may be willing to incur. The econometric analysis identified two distinct groups with contrasting preferences. The first group exhibited strong support for the current situation. Conversely, the second group expressed preferences for expanding public intervention. We further explored the sources of heterogeneity. Paradoxically, we found that education attainment and environmental knowledge in relation to consumption motivations influenced individual preferences for the status quo. However, individuals with higher pro-environmental attitudes are more likely to accept a national target of consumption reduction. They are willing to pay for demand-oriented policy instruments to complement existing supply-side measures.

1. Introduction

It is largely admitted that we have entered the Anthropocene [19, 11], an emerging period characterised by a series of global changes that have led to the current crises of biodiversity loss [16,58]. Freshwater biodiversity is especially jeopardised [22]. Among vertebrates, freshwater fish in particular have undergone rapid extinction in the 20th century [32]. Migratory species of freshwater fish, which need to migrate between environments (rivers and sea) or within river systems to complete their life cycles, are disproportionately threatened compared to other fish groups [85]. The Northern temperate eel species (*Anguilla spp.*) are a prime example of a migrating fish species at risk of going extinct. Its population has strongly declined throughout its distribution area [59]. As of writing this article, the species is almost

universally threatened [39], mostly due to the multiple anthropic pressures it is subjected to [38]. Among the factors suspected of affecting eel population, the main one contributing to the species' vulnerability is thought to be overfishing of recruiting glass eels for the aquaculture industry [72]. The IUCN [53,54,55] has classified the species as either endangered (American eel *A. rostrata* and Japanese eel *A. japonica*) or critically endangered (European eel *A. anguilla*).

Yet consumers worldwide are showing a growing interest for various eel products. Japan, where eel is enjoyed in a traditional processed dish from the Edo period called “*kabayaki*”, is historically considered to be the main consumer of eels [41]. Demand for eel-processed products outside Japan appears to have increased recently, with half of the Chinese aquaculture industry's production now supplying its domestic market [64]. Similarly, while eel is not part of the local cuisine in

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Indonesia, processed eel products are currently being developed and promoted in the country [48]. Along with Japanese cuisine's growing popularity in Western cultures, eel has settled in as a staple on sushi restaurant menus [28]. Recent studies have confirmed that European eels are being sold in food halls and markets worldwide [50], even though the European eel is listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The increase in the global demand for eel products prompted the expansion of a lucrative black market for young and wild-caught eels [41,25]. This calls for an exploration of avenues for policy interventions to protect an endangered species while it remains a consumptive good.

Recent advancements in DNA barcoding technology have the potential to greatly enhance the monitoring of imported products, especially in tracking illegally sourced glass eels. As a result, it could aid in enforcing CITES trade restrictions on eel species [79]. To further improve the effectiveness of this type of supply-side intervention, promoting sustainable alternatives to captive-bred glass eels could be beneficial [57]. However, the main problem affecting eel production is the immature state of the research on artificial reproduction technology [74]. Change in consumer behaviour [83] thus has a crucial role to play in the effort to protect endangered eel species. The main objective of this study is to examine public policy preferences regarding demand-side instruments specifically geared towards encouraging changes in eel consumption behaviour at the national level, which can complement these supply-side policies, within a policy package. One of the main arguments in favour of combining supply-side and demand-side policy instruments is the complex nature of the eel's life cycle, which comprises several critical stages [23] and therefore requires an approach fit to manage the multiple pressures exerted by markets and trade. Another important reason for combining different instruments in biodiversity conservation is that they can meet a variety of policy goals such as cost-effectiveness, efficiency, and equity [60,10]. Furthermore, public support for policy interventions increases when, rather than being proposed individually, they take the form of policy-packages presenting a set of policy instruments [87].

The literature about policy interventions to change consumer demand for endangered species specifically emphasises information-based policies to encourage voluntary behavioural change [88,52]. In this respect, awareness campaign and ecolabelling may play a significant role in raising consumers' environmental consciousness and cultivating their willingness to acquire sustainable seafood products [75,78,84]. However, the effectiveness of information-based policies to obtain consumer behaviour change is debated [62]. More coercive approaches to behaviour change control – consumption limits and levies – are also needed to target consumption habits that are particularly difficult to change [67]. However, total or partial consumption bans are very unpopular with the general public as they are perceived as potential infringements on the exercise of freedom [4,6], particularly when they targeted the consumption of wildlife products that are motivated by traditions and other socio-cultural factors [76]. Consumption bans may make the illegal market more attractive, thus leading to unintended consequences for conservation [61]. Therefore, it is essential to examine consumer acceptance of products involving a suitable substitute species if a partial or total restriction on eel consumption is to be implemented [42].

We apply the discrete choice experiment (DCE) method with 1088 Japanese citizens who had already consumed eel products to identify socially appealing policy-mix interventions [1,24] for the conservation of threatened eel species in Japan. This means that the individual is seen both as a citizen, who might support a policy that may effectively reduce market and trade pressure and thus help better preserve the species, and as a consumer, who sees opportunities and motivations to change their own behaviour [45]. As eel is an important part of Japanese culture and seafood resources [25], a better understanding of Japanese citizens' preferences for combinations of supply-side oriented and demand-oriented policies could help other countries to draft suitable

policy-package that can be used for eel conservation and reach the twofold objective of sustainable consumption of fish resources and biodiversity conservation.

The DCE method allows us to investigate general public trade-offs between different policy-package attributes, and especially between the costs that they may be willing to incur and the policy's expected benefit. It also gives insights into the acceptability of a specific policy instrument and of the combination of several of these tools. Many studies of consumer demand for sustainable fish products have already used choice experiments. Most research focuses on consumers' willingness to pay for specific ecolabels, as a tool that contributes to the conservation of fish resources ([78,84,37,12,44,70,71], to cite but a few). To our knowledge, this study is the first endeavour to examine the welfare impact of a policy package targeting the conservation of endangered fish species, by including different policy instruments - combatting illegal trade, developing research on artificial reproduction, shift to substitute species, and informing the public - directly as attributes in the choice sets [2,30,45].

Another objective of our research is to provide an in-depth understanding of potential preference heterogeneity among the Japanese public. The econometric analysis of stated choice data was carried out through a mixed Logit model and latent class model that enables us to address unobserved preference heterogeneity and to explicitly assume the presence of different groups or classes of preferences based on respondents' responses. An in-depth post-estimation analysis [3,47] provides crucial insights into the significant role of individual socio-demographic characteristics, environmental knowledge, consumption habits, and pro-environmental attitudes in distinguishing different groups of preferences.

The remainder of this paper is organised as follows: the next section provides some details on the Japanese context; Section 3 outlines the survey and introduces the econometric method applied; Section 4 presents its results; and Section 5 concludes and offers policy recommendations.

2. Materials and methods

The discrete choice experiment method has become a prized tool in environmental valuation studies [15], especially for the protection of threatened and endangered marine species [86]. The DCE is a quantitative survey technique designed to elicit individual preferences. Individual respondents are asked to make a number of choices between different hypothetical management/policy scenarios defined by their attributes, with different levels proposed for each attribute. Choice data obtained with the DCE survey are then used to infer the perceived utility of each of these attributes for individual respondents, the trade-offs they make between these attributes, and the overall benefit of the policy scenario. The DCE process follows four steps: selecting attributes and defining their levels; designing the experiment and constructing the choice sets; designing the questionnaire and defining the sampling strategy; and applying the econometric estimation method for data analysis.

2.1. Policy scenario's attributes

The policy package scenario was designed with the objective of achieving a more effective protection of eel species. In Japan, two public intervention tools are already being promoted to better protect eel stocks, although they have yet to be materialised: improved monitoring of imported products to trace illegally sourced glass eels and the development of research to unlock artificial eel reproduction [74].¹ Our first attribute is therefore: "Controlling imported products to combat illegal trade". This attribute refers to the additional effort that the

¹ Additional details on the Japanese context are provided in Appendix A.

Japanese government can put into this measure compared to the current situation. Respondents were informed that Japan must verify the origin of imported eel products, some of which may be sourced from illegal fishing or illegal imports of species prohibited from trade. However, achieving this remains very challenging. We assigned two levels to this attribute: low increase and high increase. The second attribute “Developing the research on artificial reproduction of eels” was presented to respondents as being either present in the policy package or absent from it.

To complement these supply-side policy interventions, we introduced demand-side policy instruments designed to achieve a change in eel consumption trends. We thus included, as one of the demand-side policy attributes, the target levels for national eel consumption reduction defined in the form of a reduction in eel consumption by 2030, set as a percentage of current consumption. The attribute had three levels: 75 %, 50 % and 25 % of current consumption. The reference situation (status quo) was the absence of change. Recent applications of choice experiments demonstrate that households tend to accept policies with more ambitious environmental objectives. However, as the Japanese government can choose which policy instruments to put in place to achieve their objectives, it is especially important to find out which instruments are more acceptable. A fourth attribute called “information-based policies” was described in the form either of an information campaign aimed at raising environmental awareness among the general public, or of a product origin and processing certification. Eco-certification relies on an obligation placed on producers to inform consumers about the traceability and sustainability of their seafood products, to ensure that eel products are processed using environmentally sustainable practices. In our DCE, one attribute corresponds to “a shift to a substitute species”. A “substitute species” attribute was thus presented to respondents: one of three less vulnerable fish species that could potentially take eels’ place in “*kabayaki*” preparations, namely Kindai catfish, Sanma, and Conger eel.²

A point of interest in this study is whether the public might accept additional policy interventions to protect eel species, and namely the inclusion of a tax instrument resulting in higher prices for consumers. The average price per 100 g of this emblematic Japanese dish is referenced in national statistics (<https://www.e-stat.go.jp/>, 2023). In 2021, it was around JPY 1276. The last attribute corresponds to the tax instrument. It was described as an “Increase in the average price for 100 g of *kabayaki*” compared to the current price [89]. The price increase from this average was made significant enough to influence choices (10 %, 25 %, 50 %, 100 %).

These policy instruments and their levels were selected based on the grey and scientific literature, and validated through interviews with some key informants such as researchers, restaurant managers and consumers. The scenarios’ attributes and levels are summarised in Table 1 (presentation of attributes to respondents is provided in Appendix B).

2.2. Choice experiment design

We offered respondents a series of choice sets with different levels for each policy attribute and determined their willingness to pay (WTP) for individual eel conservation policy attributes and scenarios. The choice sets were obtained using a D-efficient experimental design and were generated with the Ngene software (Choice Metric, 2018). With a total of 10 parameters and two alternatives, there had to be a minimum of five choice situations. But as this number of choice sets had to be dividable not only by the number of attributes but also by the number of levels associated with each attribute, there had to be a minimum of 12 choice situations. The D-efficiency criterion of the experimental design selected was 0.27. The 12 choice situations were divided into two blocks of six

Table 1
Attributes and attribute levels for eel species conservation policies.

Attributes	Attribute levels
Increased Control on Imports	Current level (Status Quo) Low increase High increase
Development of research on artificial reproduction	Yes (Status Quo) No
Global quantity of eel consumed in Japan by 2030	Current quantity (Status Quo) 25 % of the current quantity 50 % of the current quantity 75 % of the current quantity
Shift to substitute species	No shift (Status Quo) Shift to Kindai catfish Shift to Sanma (Pacific saury) Shift to Conger eel
Information-based policies	No specific policy (Status quo) Eco-labelling Public awareness campaigns
Tax instrument (Increase in the average price of 100 g of <i>kabayaki</i>)	No Tax (Status Quo Only) ¥1410 (10 % higher than the current average price) ¥1600 (+25 %) ¥1920 (+50 %) ¥2560 (+100 %)

choice cards. Blocks were assigned to respondents randomly [46]. Respondents were presented with six repeated choice situations, each including two alternative policy-mix scenarios (Options 1 and 2) and a status quo situation. The inclusion of a status quo alternative (no additional policy intervention, i.e. the current situation) is recommended for the valuation of public goods [40]. It can also make the choice exercise more realistic and avoid forcing participants to choose one of the proposed public interventions. An example of a choice set is shown in Table 2.

The choice experiment method makes it possible to obtain environmental protection preferences directly from individuals. In this framework, individuals are expected to make their choices based on their pre-existing knowledge and experience. If the people taking part in the study are not sufficiently informed about the expected benefits of environmental protection, they will underestimate the importance of the protection policies presented to them [8,73]. Furthermore, the provision of information improves respondents’ understanding of complex evaluation problems [20]. In other words, in stated preference methods, respondents make their choices with the information provided by the researcher in the survey protocol. In this study, we provided all respondents with detailed information on the eel value chain (from production to consumption), to formally address the surveyed consumers’ potential lack of information and knowledge about the eel trade value chain when faced with complex or unfamiliar choices.

To ensure that all respondents received identical information before making their choices, the choice-testing protocol began with a video followed by a short written presentation of all the information needed to reveal preferences. The video provided general information regarding the context, starting with the Japanese eel’s status as an endangered species and the decline of its population. A talk was then given about eel consumption in Japan: how much of it is consumed, the eel’s origin (fishery, farming, imports), the main dish for which it is used (*kabayaki*), and the average price of eel. The video format also enabled us to communicate more effectively on complex conservation issues, within a fairly short space of time (the video lasted less than three minutes) and in an illustrative way. The respondents could not proceed to the rest of the questionnaire without having finished watching the video. We introduced two control questions after the video to verify that respondents had paid attention to its content. The video was produced with the help of the company The Translation People. The written material detailed the instructions: respondents had to choose between several scenarios, each containing six criteria with different levels.

² <https://www.seafoodsource.com/>, 2023.

Table 2
Example of a choice set.
















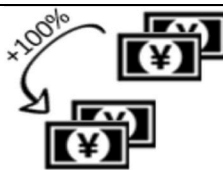


	Option 1	Option 2	Option 3
Global quantity of eels consumed in Japan by 2030, compared to the current quantity (around 50,000 tons)	 25% of the current quantity	 Current quantity	 Current quantity
Substitute species	 No substitute species	 Sanma	 No substitute species
Development of research about artificial eel reproduction	 Yes	 No	 Yes
Informing the public	 Set up a largescale public awareness campaign	 No development of the access to information	 No development of the access to information
Fight against illegal eel trade by controlling imports	 Low increase	 High increase	 Current level
Increase of the average price for 100g of kabayaki compared to the current one	 2,560¥ (+100% from the average price)	 1,410¥ (+10% from the average price)	 1,280¥ (current average price for 100g of kaboyaki)
Your choice:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Table 3 –
MIXL in preference-space and Two-classes LCL models.

	Mixed Logit		Latent Class logit	
	Mean	Standard-deviation	“Business as usual”	“Pro-conservation”
Status quo	−0.705*** (0.097)	1.761*** (0.076)	0.502*** (0.181)	−1.117*** (0.093)
Target for consumption reduction in 2030	0.080 (0.063)	0.366* (0.195)	−0.060 (0.170)	0.118* (0.061)
Substitution with Catfish	−0.105* (0.056)	0.121 (0.225)	−0.665*** (0.138)	0.075*** (0.061)
Substitution with Sanma	−0.144*** (0.069)	1.067*** (0.099)	−0.995*** (0.155)	0.192*** (0.060)
Substitution with Conger eel	0.268*** (0.053)	0.495*** (0.115)	−0.322*** (0.129)	0.406*** (0.056)
No research development	−0.327*** (0.039)	0.476 (0.073)	−0.306*** (0.101)	−0.251*** (0.034)
Increase awareness with a label	0.136*** (0.048)	0.014 (0.102)	−0.055 (0.126)	0.176*** (0.049)
Increase awareness with a campaign	0.200*** (0.049)	0.013 (0.088)	−0.001 (0.128)	0.235*** (0.050)
Low increase in control of illegal trade control	0.088* (0.047)	0.018 (0.107)	0.115 (0.116)	0.069 (0.047)
High increase in control of illegal trade control	0.081* (0.045)	0.042 (0.082)	−0.172 (0.119)	0.113*** (0.047)
Increase in the price of kabayaki	−9.202*** (0.380)	0.178 (0.590)	−0.005*** (0.001)	−0.001*** (0.001)
Class membership			−0.858*** (0.092)	
Class Share			30 %	70 %
AIC			13,050.64	
BIC			13,231.93	
Log-likelihood	−6484		−6502	
Number of respondents	1088		1088	
Number of observations	19,584		19,584	

Note: Standard-Error in parenthesis; ***significant at 1 %; **significant at 5 %; *significant at 10 %.

These levels were specified, and respondents were asked to indicate which option they found most satisfactory.

2.3. Data collection and survey design

A nationwide survey was administered online, in February 2023. The sample was drawn from an online access panel provided by a professional web survey company, TGM Research. The questionnaire was available and optimized for smartphones. While the use of the Internet and of a video tool opens our research to debate about work on the perception of biodiversity [65] and a potential information bias [31], these tools enabled us to bring together a relatively large sample of Japanese eel consumers spread across the country. The questionnaire and online tools were developed in Japanese. Data were collected by using a regional quota sampling method. The respondents were pre-screened based on their region of residence and the corresponding town density level. We are aware that the quota sampling method is a non-probability sampling approach.

The questionnaire began by collecting respondents’ socio-demographic characteristics. In the second section, it asked them a series of questions about their environmental practices and values. The third section consisted of questions relating to their general knowledge of, or familiarity with, endangered species and their protection. This was followed by a series of questions relating to their knowledge of eels, the ecological situation of this species, and their own consumption of this species. These questions were intended to encourage respondents to think about eel protection and prepare them for the choice experiment. The last section featured the video and was devoted to the choice tasks.

2.4. Econometric modelling framework

It is now standard practice to describe the extent to which respondent i benefits from scenario j of choice set n using a random utility function U_{ijn} comprised of the impact of the attribute levels and a sto-

chastic component ε_{ijn} . More specifically, we chose to use dummy-coding technique to estimate the main impact of each non-monetary attribute level on respondents’ choices. The lowest level of each of the non-monetary attributes (level of the status quo alternative) was the reference. The utility of the status quo scenario $U_{i,j=3;n=1,...,6}$ is only a function of the alternative specific constant because the value of the other attributes is set to zero. The utility function underlying the choice process can be described as follows:

$$U_i(j, n)_{j=1,2,3;n=1,...,6} = \alpha ASC_STATUS_QUO + \beta_1 QUANTI_{jn} + \beta_2 SUB_CATFISH_{jn} + \beta_3 SUB_SANMA_{jn} + \beta_4 SUB_CONGEREEL_{jn} + \beta_5 NO_RESEARCH_{jn} + \beta_6 AWAR_LAB_{jn} + \beta_7 AWAR_CAMP_{jn} + \beta_8 ILLEGAL_LOW_INCR_{jn} + \beta_9 ILLEGAL_HIGH_INCR_{jn} + \beta_{10} COST_{jn} + \varepsilon_{ijn} \quad (1)$$

When faced with the different alternatives $j; j = 1, 2, 3$ within each choice set $n, n = 1, 2, \dots, 6$, the respondent is assumed to select the alternative that gives them the most utility. The conditional logit is the first candidate model to estimate the choice probabilities in Equation (1). Assuming that the error terms ε are independently and identically distributed (IID) and follow the Gumbel distribution, the probability that alternative j would be chosen from choice set $n, n = 1, 2, \dots, 6$ is calculated with the following equation:

$$\pi_i(j, n) = \frac{\exp(\beta X_{jn})}{\sum_{j=1,2,3} \exp(\beta X_{jn})} \quad (2)$$

The probability of the observed sequence of choices for the $n, n = 1, 2, \dots, 6$ choice sets is quantified as follows:

$$P_i = \prod_{n=1,2,\dots,6} \pi_{ij=1,2,3}(j, n) \quad (3)$$

Choosing an econometric method of estimation to deal with the heterogeneity of individual choices is not an easy task when carrying out a discrete choice experiment. Assumptions made at the specification stage can have important influences on parameter estimates, and as such on willingness to pay (WTP) measures. Two of the predominant discrete

Table 4
Marginal WTP Values.

	Mean (MXL wtp- space)	Business as usual	Pro- Conservation
Status quo	-	1487* (838)	-
Target for consumption reduction in 2030	736 (756)	-	1509 (1042)
Substitution with Catfish	-	-	966 (866)
Substitution with Sanma	-	-	2460* (1379)
Substitution with Conger eel	2933*** (1309)	-	5200** (2601)
Increase awareness with a label	1466* (813)	-	2258* (1324)
Increase awareness with a campaign	2207*** (1049)	-	3015* (1601)
Low increase in control of illegal trade control	735 (536)	341 (351)	882 (677)
High increase in control of illegal trade control	807 (596)	-	1454 (953)

Note: Standard-Error in parenthesis; ***significant at 1 %; **significant at 5 %; *significant at 10 %.

choice models used to study individual preferences and to capture preference heterogeneity, and especially unobserved heterogeneity, are the mixed logit (MXL) and latent class logit (LCL) models [29]. MXL models assume randomly distributed parameters, and LCL models group individuals in classes according to their preferences. The results of the latent class model specification highlight differentiated behaviour across the preference groups. Moreover, evaluation targeting specific groups is key to formulating public policy prescriptions.

We start our analysis by estimating the classical mixed logit model for which all the coefficients are random parameters. This means that we estimate our choice model within preference space by considering that all attribute parameters were allowed to be normally distributed over individuals, except the cost attribute parameter which was assumed to follow a negative log-normal distribution.

The LCL model is based on a joint estimation of the latent construction of preference heterogeneity and policy scenario choices relating to scenarios' attributes. If we assume the existence of S classes of preferences within our population, the probability that a randomly chosen individual i will fall in class s and choose the alternative j for the six sequences of choices, the unconditional choice probability for this sequence of choices for respondent i , is therefore given by the following equation:

$$\pi_i(s, j, n) = \sum_{s=1}^S \pi_s \left(\prod_{n=1}^6 \pi_i(j, n) \right) \quad (4)$$

where π_s represents the prior class probability membership of each individual, which also follows the multinomial logit model. π_s contains a constant-only model for class membership.

The Marginal Willingness to Pay (MWTP) measure expresses how welfare is affected by a change in a specific policy attribute. It is defined as the maximum amount of income that an individual is willing to pay to see an improvement in a particular policy attribute. We calculate MWTP values using a mixed logit model in WTP space, which has been shown to provide more accurate WTP measures than mixed logit in preference spaces where the cost coefficient is assumed to have a log-normal distribution [36]. In an LCL model, we can obtain class-specific marginal WTP estimates by looking at the ratio between the class-specific coefficient of a policy attribute and the negative of the class-specific cost coefficient.

3. Results

3.1. Sample characteristics

We removed 211 individuals, including respondents who claimed that they did not know about eels, respondents who systematically opted for the status quo on the grounds that the choice was difficult or very difficult or that they did not feel concerned (protests), and respondents who were not the ones making the decisions and their preferences were therefore biased. The final sample contained 1088 rural and non-rural respondents.

The average age of our sample was around 49 years old. Even though the goal was not to gather a representative sample of the Japanese population, it is worth noting that this average age is only one year above the national average. However, there were more men than women (66 %), which is not the case among the Japanese general population. The level of education was slightly higher than the national level – the majority (63 %) of respondents were university graduates. The average household income was around 4.46 million JPY, which is significantly higher than the national average household income of 3.74 million JPY. More than 37 % of our respondents live in rural area.

To measure respondents' level of pro-environmental behaviour, we asked them if they sorted their waste – 76 % of them claimed to; 24 % of respondents have declared that they avoid buying products with plastic packaging. We then measured respondents' concerns in terms of their diet: if they claimed to buy organic (10 % did), or to be reducing their meat consumption (15 %). Respondents' level of environmental knowledge was also measured using two questions. They were first asked to give their opinion about what constitutes an endangered wild species by answering a multiple-choice question. If they gave one or more correct answer(s), they were considered to know what an endangered species is. They were also asked to give their opinion about the status of the eel by answering a multiple-choice question. They were considered to know about the eel's status as an endangered species if they checked the corresponding answer. While most of the respondents (66 %) seemed to have a fairly clear understanding of what constitutes an endangered species, only a minority of them knew that the eel is one (39 %).

The NEP scale is composed of 15 statements assessed on a seven-point Likert scale (from 1 for the "strongly disagree" answer to 7 for "strongly agree"; with 4 corresponding to "I do not know") and grouped into five core facets: "limits of economic growth"; "anti-anthropocentrism"; "fragility of the natural balance"; "rejection of human exceptionalism"; and "eco-crisis". Seven items (even items) were negatively narrated. In this way, a high average score always corresponds to a pro-environmental attitude. We computed the average score for each of the five value types, and the average score for the full NEP scale. The mean scores are under 5, which indicates that indifferent responses (for score 4) are prevalent.

Most respondents consume *kabayaki* primarily for taste (63 %), 14 % do so for cultural reasons and 12 % for health reasons. More than half of respondents (53 %) said they eat eel at a specific event, and 33 % said they only eat it occasionally.

3.2. Preferences for policy instruments

The results of the estimation of the conditional logit model for the full sample are provided in Appendix C. On average, respondents in our sample were favourable to the implementation of policy-mix schemes aimed at the conservation of eel species. More specifically, the ASC (Alternative Specific Constant) for the status quo alternative is negative and significant. Results also show that on average, individuals did not reveal any preference for a specific target of eel consumption reduction. The coefficient of the attribute is positive but non-significant. Regarding the consumption of substitute species, the results indicate that, on average, the public has a strong preference for Conger eel as a substitute

for eel. All other things being equal, a scenario that does not involve the development of research into artificial eel reproduction is associated with a lower utility than one that does. The coefficient of the variable “No Research” is significant and negative. On average, respondents ascribe positive value to information-based instruments. They support increasing efforts to combat illegal trade, but they are not fully convinced by a substantial increase. The coefficient for the cost attribute is significant and has the expected sign.

Modelling results from both the MXL in preference space and the LCL, that accommodate unobserved heterogeneity, provides a more nuanced picture (Table 3). When run through the MXL model, results confirm that respondents generally show a strong preference for implementing any additional conservation policy, as indicated by the negative coefficient of the status quo option. Overall, respondents are willing to pay for a policy-action scenario. However, the standard deviation of the status quo scenario is higher than its corresponding mean value, suggesting substantial heterogeneity in respondents’ preferences in terms of policy scenarios for eel conservation. This indicates that achieving “eel species conservation” through additional policies targeting the supply side and the demand side of the market and trade is not always desirable for people, considering the trade-offs between the benefits of eels’ conservation and the costs it could incur. We have observed that respondents are on average not sensitive to an overall consumption reduction target for 2030; the mean parameter is not significant. However, preferences are heterogeneous (the standard-deviation parameter is significant). We also found a positive valuation of the Conger eel as a substitute species, with respondents however showing strong heterogeneity. The results in Table 3 show that policy packages that involve information-based incentive mechanisms either for environmental campaigns or eco-labelling were homogeneously preferred. The coefficient parameters are positive in these cases, and the corresponding standard deviation parameters are not significant. There is also a homogeneous preference for additional control over imports, although coefficient parameters are non-significant in this case. The mean parameter of the cost attribute is significant and has a negative sign, and its standard deviation is zero, which indicates that the effect of price is homogenous across individuals.

Results from the mixed logit show substantial unobserved heterogeneity in preferences among respondents. To further examine the drivers of heterogeneity, we estimated an LCL model that allows respondents to be clustered around common policy-package preferences and individual characteristics. To determine the optimal number of classes, we tested 2-, 3- and 4-class solutions. However, the 4-class model does not converge. We used the two criteria most commonly used to decide between the two models (2- or 3- class solution): the minimum Akaike Information Criterion (AIC) and the minimum Bayesian Information Criterion (BIC). These statistics point toward the 3-class model which resulted in a positive cost parameter estimate for one of the identified classes (See Appendix D). We thus followed [5] to conform with the economic theory of rational choice behaviour of demand model and selected the two-class model to account for the heterogeneity of preferences.

At the sample level, respondents had a 30 % probability of falling in Class 1, and 70 % in Class 2. The results from Table 3 indicate that respondents from the two classes have different preferences for the status quo and most of the non-monetary attributes. The cost attribute is significant and has a negative sign for both classes. However, respondents in the first class are extremely sensitive to cost. The coefficient for the cost attribute is significantly larger.

Class 1 (we named the *Business as usual class*) corresponds to individuals who have a positive perception of the current situation. The ASC of the status quo alternative is positive and significant. Target values for reduction in eel consumption in 2030 have a negative coefficient parameter effect but are not an attribute that influences the perceived utility of a policy scenario in this class. These respondents show a strong aversion to a shift to eel substitute species. All estimates

for the three substitutes are negative and significant. This pattern clearly signals a strong preference for eel products, indicating a positive attitude towards continued consumption. This class of individuals have a negative view of a public intervention scenario that would halt research into artificial eel reproduction. Awareness instruments and additional efforts to combat illegal trade have no influence on utility in this class. The negative impact of the increased price of *kabayaki* on utility is much greater than for Class 2.

Class 2 (we named the *Pro-conservation class*) brings together individuals who prefer extensive changes in eels’ conservation policy compared to the current situation. Moreover, compared to Class 1, respondents perceive consumption reduction targets to be crucial for the conservation of eel species. Individuals report a gain of utility if Sanma or Conger eel are promoted as substitute species if a limited consumption of eels is implemented. As in Class 1, individuals show a decrease in perceived utility when research on artificial eel reproduction is stopped. The estimates show that this loss is much lower for this class than for Class 1. Finally, in this class, individuals are very sensitive to awareness tools and derive positive utility from significant increases in the control of import products.

To gain further insights into policy preference heterogeneity, we characterised each class by reporting descriptive statistics and testing for significant differences (see Appendix E). Individuals were assigned to the class to which they had the greatest posterior probability of belonging. Four main variables are often closely studied in the field of environmental policy valuation: respondents’ education level, their gender, age and income – all as proxies of personal capabilities for understanding scientific issues –, and the resources required (time, financial budget) for the environmental cause. Starting with individual socio-demographic characteristics, only education attainment showed significant differences between two classes. Class 1 respondents were more likely to have a higher education degree, and to live in rural areas. It is worth noting that knowledge of what constitutes an endangered species increases the likelihood of belonging to Class 1. Respondents in Class 1 are more likely to consume eels for their taste, only occasionally, and for cultural reasons. Individuals that score higher on all the Pro-NEP items and on each of the five facets are predominantly found in Class 2. Most respondents who avoid buying products with plastic packaging are in Class 2, and the share of respondents who declared reducing their meat consumption is also higher in this class.

3.3. Marginal WTP for policy instruments

Table 4 summarises the marginal WTP values representing the amount that individuals would be willing to pay in relation to a specific policy instrument. The valuation of the current situation for Class 1 is ¥1487 which is equivalent to an increase of about 10 % of the actual price used as reference. The marginal WTP for a specific policy instrument is made up of use value (consumption) of eel species and their conservation. We retain significant mean WTP estimates calculated with mixed logit in wtp-space for the full sample and WTP values for Class 2 of the latent class model for interpretation. On average, respondents would be willing to pay between ¥2933 (on average) and ¥5200 (for Class 2) to see Conger eels being promoted as substitute species. The MWTP for Sanma as a substitute species is about ¥2459. Conger eel is associated with higher benefit. The WTP estimates obtained from the LCL model emphasises this finding. We found that the MWTP for implementing eco-labels range between ¥1465 and ¥2258, and between ¥2206 and ¥3014 for awareness campaigns. WTP values are non-significant for import control policies.

4. Discussion and conclusion

It is critical that private citizens both consume in environmentally friendly ways and support conservation policy, since combining these actions can lead to sustainable fisheries and more effective conservation

of a threatened species. Our econometric analysis reveals a significant share of respondents (about one third of the sample) expressed a refusal to recognise eel consumption as an environmental problem to be tackled through additional public intervention. Furthermore, our economic valuation suggests that these respondents want to continue consuming *kabayaki* under current policy intervention and are willing to pay a slight increase in its price. Conversely, our estimates indicate a strong preference for moving away from the status quo (in about 70 % of respondents). Overall, this class of respondents significantly prefer setting quantitative reduction targets for eel product consumption by 2030, while they are unwilling to bear an additional tax for it. They also advocated the implementation of demand-side policy instruments to complement supply-side tools.

However, considering that both supply-side and demand-side policies were presented within a policy package, the estimated welfare values show that, in terms of the amount respondents grouped in pro-conservation class would be willing to pay to see policies being implemented, the benefit from demand-side actions is higher than that from supply-side oriented policies. Particularly, we found that, in general, respondents have a positive preference for additional effort to combat illegal trade but are not willing to pay for it, when compared with the *status quo*, since there is already some level of control in place, including the enforcement of regulatory measures. In this respect, Japan has imported a considerable amount of IUU fishery products including Anguillid eel species. [56] estimated that 24–36 % of seafood imports to Japan in 2015 contained material of illegal and unreported origin, valued at \$1.6 to \$2.4 billion. In fairness, it is possible that the amendment to the Fisheries Act and the implementation of the Proper Distribution Act could lead to a serious crack down on IUU glass eel fisheries in Japan's waters. However, the management of glass eel imports into Japan will not be substantially improved, as the Fisheries Act is only effective for domestic glass eel fisheries, and glass eels imported from other countries are not subject to the Proper Distribution Act so far. Documents regarding the Proper Distribution Act describe glass eel as 'eels smaller than 13 cm' and do not specify the species. Thus, listing glass eels in Class II would be beneficial not only for the Japanese eel but also for other Anguillid eel species.

In summary, improved control over glass eel imports can help in the conservation and sustainable use of Anguillid eels, and, overall, the respondents in this study were favourable to the introduction of more stringent control on glass eel imports *versus* maintaining the status quo. However, it may be assumed that the general public in Japan, as well as in the most of other countries, does not possess detailed knowledge about such issues. Their lack of knowledge might lead to indifference toward the different levels of this attribute [35]. Higher levels of perceived uncertainty attached to such policies (i.e., the hypothetical bias) can also help explain lower WTP values even indifference in preferences [33]. However, these require further investigation.

The strongest preferences were found for substitute species, for which Conger eel products were identified as an attractive substitute for eel products, to be developed for commercial purposes. This indicates that for pro-conservation citizens, there is no potential for conservation benefit to wild-caught species without a demand substitution with a non-threatened species [34]. We also found that information-based interventions such as awareness campaigns or fish product labelling should also be implemented. However, public awareness campaigns are preferred over eco-labelling schemes. This may depend on the prominence of a policy instrument such as environmental education in Japan [63], and worldwide [80], but also on the lack of trust on eco-labelling schemes [27]. In Japan, there are different wildlife-friendly labels in place, but they are not yet widely used [43]. All survey participants would experience clear disutility if research on artificial reproduction of eels were halted. However, the loss of utility would be significantly greater for individuals in class 1, who are looking for more opportunities to continue consuming eels under the current policy situation.

In terms of preference heterogeneity, the only socio-demographic

variable associated with class preferences is education. The influence of age, gender and income on individual preferences was not found to be statistically significant. In other words, these variables, which in most cases would be expected to play a significant role, do not help to explain the heterogeneous nature of preferences for policies targeting a universally threatened yet consumed species. Individuals with higher education degrees are more likely to be members of class 1. Individuals with university degrees tend to adhere to more balanced diets [51]. Furthermore, they view the consumption of fish as one of the most beneficial dietary patterns in terms of both human health and the environment [81].

In examining the influence of environmental knowledge on preferences, we focused on knowledge of threatened species, distinguishing between knowledge of common threatened species and awareness of the eel's status as a threatened species. Members of Class 1 exhibited higher levels of knowledge regarding endangered species. The results appear to be paradoxical, yet this aligns with some research on wildlife product consumption trends, which indicates that awareness of environmental threats is not consistently associated with pro-environmental behaviour [49]. The finding that respondents in Class 1 are particularly characterized by their consumption habits provides a potential explanation for this. Despite possessing more precise information regarding endangered species, the consumption of eels is still regarded as conferring additional benefits, including cultural value, nutritional value, health benefits, and taste [68]. Additionally, they are occasional consumers. All these results suggest that raising public awareness and improving information and education on the conservation of endangered species will not be as effective as expected in increasing individual willingness to contribute to voluntary consumption behaviour change. This is particularly true for individuals who belong to this class of consumers. Finally, knowing the ecological status of eels does not appear to influence policy preferences among respondents in either of the two classes. One potential explanation for this phenomenon is the diverse motivations underlying the consumption of eel products.

In many cases, conservation and biodiversity protection can have a more direct impact on people living in rural areas, where the habitats of many species to be protected are located. These rural households are less inclined to support conservation actions that could have a negative impact on them [7]. In this study, the class who prefers the current policy includes higher proportion of Japanese individuals living in rural areas. These consumers living in rural areas were closer to eel fishing activities, and therefore likely to be more sensitive to the preservation of eel production activities as a local heritage [64].

The influence of environmental concerns was investigated. In this study, the focus was on the active dimension of environmental concern, namely pro-environmental practices. It can be hypothesised that present pro-environmental behaviours can lead individuals to be more concerned about the environment, in order to maintain a degree of coherence in their actions [82]. Consequently, a positive effect between pro-environmental behaviours can be expected. We selected avoidance of plastic packaging, which is directly connected with sustainable consumption [9]. Furthermore, the nature of protein intake may be indicative of diet sustainability [77]. Therefore, people's desire to reduce their meat consumption could be linked to their environmental consciousness [66]. Our class 2, which comprises pro-conservation respondents, displays a higher proportion of individuals who have adopted such pro-environmental practices. However, it is possible that respondents may have declared such practices in order to maintain a positive self-image [21]. Individuals' general beliefs and value orientations might also influence their preferences. The final step of our analysis thus examined how different environmental concerns and ecological worldviews are across classes using the New Ecological Paradigm (NEP) scale items, an indicator of environmental values and concerns that is commonly used by economists [90]. Several valuation studies using the NEP scale to examine endangered species conservation policy [75,17] highlight that individuals who endorse this paradigm

consistently engage in behaviours that align with it. We found that individuals displaying stronger pro-NEP attitudes show a strong aversion to the status quo, which was reflected in their classification in class 2.

In conclusion, these findings may support the implementation of a policy package in Japan, including research on artificial reproduction, shift to substitute species, and public awareness campaigns. However, careful consideration is required to develop actual measures because our respondents' views may not be representative of those of all Japanese citizens due to methodological limitations, and groups with different opinions were found among the respondents. Despite such limitations, our results provide some useful insights when considering Anguillid management in Japan, and the high relevance of engaging in controversial political discussions about eel species conservation in Japan. It is recommended that future research agenda include robust comparative studies between different countries. Furthermore, the specific role of environmental knowledge and the impact of delivering information through video represent a legitimate and important areas of for future research. The presence of individual strategic behaviour associated with the presence of the status quo in the choice experiment method also requires further investigation [13,14].

Appendix A. - The Japanese context

In Japan, illegal catching and distribution of glass eels are considered as a major threat to the Japanese eel, a freshwater eel species native to East Asia. For example, during the 2014–2015 fishing season, the reported catch accounted for only 37 % of the total volume of glass eels caught in Japan's domestic waters. The remaining 63 % (equivalent to 9.6 tons of glass eels) were traded through unlawful means, i.e., IUU (Illegal, Unreported and Unregulated) fisheries. Additionally, three tons of imported glass eels are believed to have been smuggled from third countries of origin through Hong Kong and then exported legally to Japan [18]. In total, about two-thirds of the glass eel input into eel farms in Japan during that fishing season is highly likely to have been unlawfully fished and/or traded.

The Japanese Fisheries Act was recently amended, and fines on illegal glass eel fishing in Japan's waters were raised by a factor of 300 (up to 30 million JPY). This amendment came into force for glass eel fisheries in Japan in December 2023. Moreover, Act No. 79 (2020) on Ensuring the Proper Domestic Distribution and Importation of Specified Aquatic Animals and Plants (hereafter referred to as the Proper Distribution Act) was promulgated in 2020 and went into effect at the end of 2022 to combat the distribution of products originating from IUU fisheries. The act defined Class I and II aquatic animals and plants that are particularly vulnerable to IUU fishing; the former includes domestic organisms fished in Japan's waters, and the latter includes organisms that are fished by foreign-flagged vessels under foreign laws. Glass eels are listed as Class I but not as Class II so far, with a three-year moratorium (implementation is expected in 2025). Glass eels that are fished in Japan will be subject to this act, while imports from outside Japan will not.

Regarding the quantity of Japanese eel consumed, China, Japan, South Korea, and Taiwan have limited glass eel input into aquaculture ponds (The Bureau of Fisheries of the People's Republic of China *et al.* 2014). While the limit set between these four participants is not legally binding, Japan has established a legally binding domestic regulation to ensure that its glass eel input does not exceed their quota. However, some areas remain to be improved for the conservation and sustainable use of Anguillid eels. First, glass eels smuggled from a third country of origin are thought to be imported into Japan. Second, for the Japanese eel, the Japanese Government controls glass eel input into domestic aquaculture ponds based on said agreement between China, Japan, South Korea, and Taiwan (The Bureau of Fisheries of the People's Republic of China *et al.* 2014). However, critics point out that this limit has not decreased Japanese eel consumption because the four participants' cumulative ceiling is about twice as large as the actual glass eel catch [41]. Third, as Anguillid eel species other than Japanese eel have been imported to Japan and consumed there [26], careful consideration should be paid to other eel species to avoid excessive consumption and/or illegal activities. For instance, 152 tons of American eel fry was reportedly imported to East Asia in 2022 [69], while the glass eel input of Japanese eel was approximately 47 tons.

CRedit authorship contribution statement

Kenzo KAIFU: Writing – review & editing, Validation. **Hermione FROEHLICHER:** Writing – original draft, Methodology, Funding acquisition, Data curation, Conceptualization. **Tina RAMBONILAZA:** Writing – review & editing, Validation, Methodology, Conceptualization. **Françoise DAVERAT:** Writing – review & editing, Validation, Conceptualization.

Declaration of Competing Interest

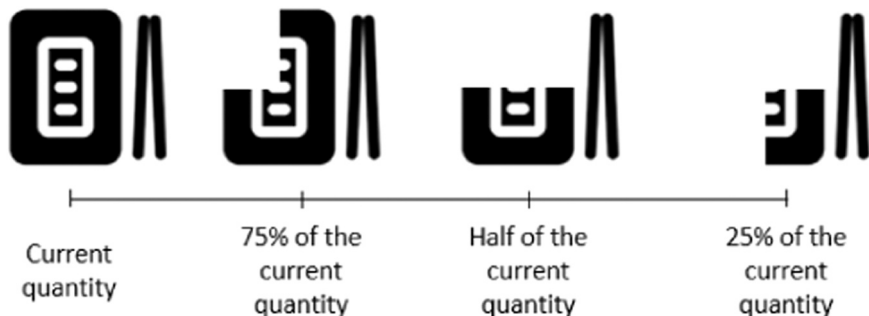
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

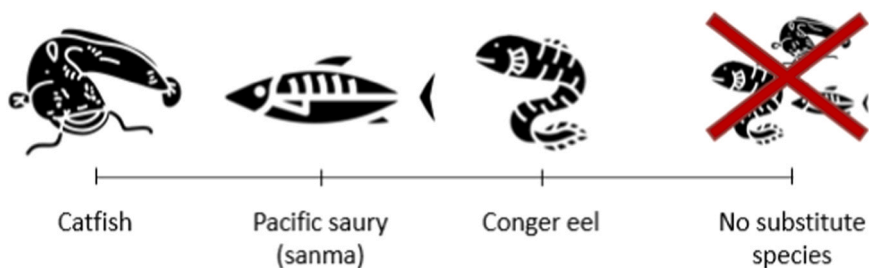
Data will be made available on request.

Appendix B. - Definition of the attributes for respondents

You will now have to choose between several scenarios. Each one contains 6 criteria which can vary to different levels:
Criterion 1: the global quantity of eels consumed in Japan by 2030, compared to the current quantity (around 50,000 tons).
You may choose between four different levels of consumed quantity of eel:



Criterion 2: the substitution of part of the eel consumption by other species.
You may choose between three different substitute species or choose not to substitute eel:

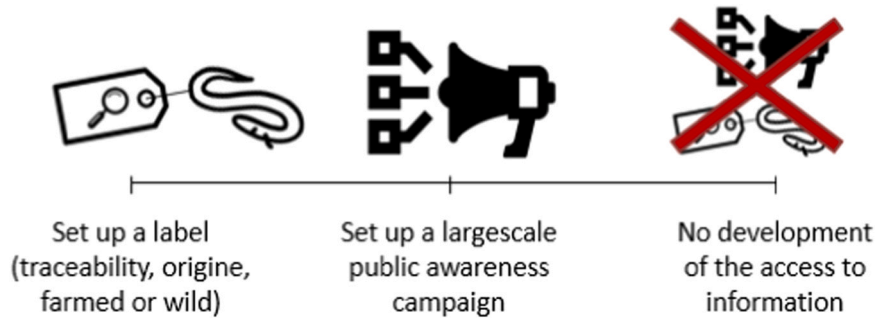


Criterion 3: the development of research about eel reproduction
It would allow the eel aquaculture by making artificial reproduction. You may choose to encourage the development of this research or not:



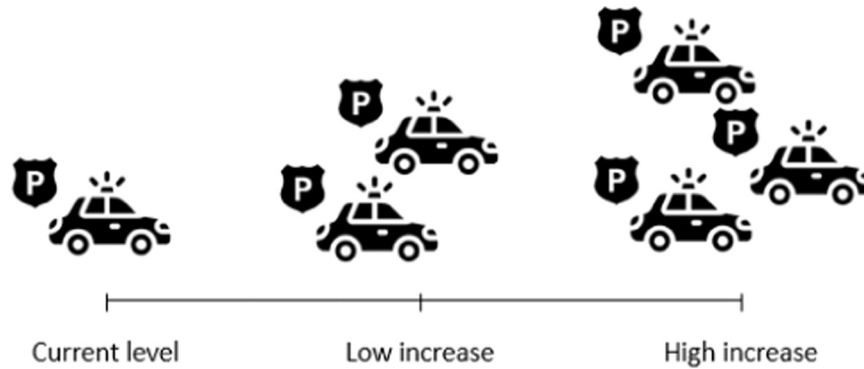
Criterion 4: the public awareness

You may choose between setting up a label to follow the product from the beginning to the end (you would be able to know its origin, if it is wild or farmed, etc.), or setting up a largescale public awareness campaign or to not develop the public access to information:



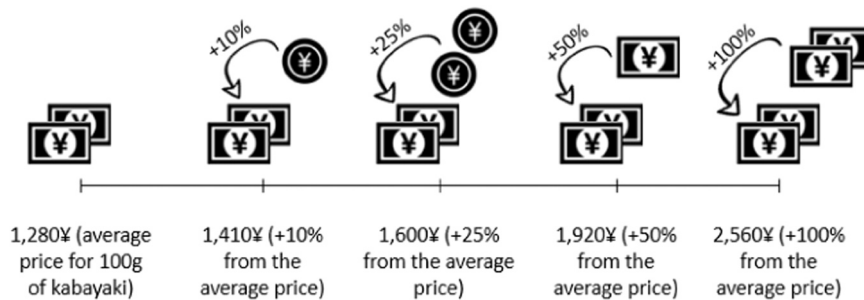
Criterion 5: the fight against illegal eel trade by controlling imports

You may choose between 3 different levels including the current level, a low increase of this current level or a high increase. This level cover all the resources: staff, budget, equipment, etc.



Criterion 6: the average price for 100 g of kabayaki

The reference price is the average price of 100 g of kabayaki in 2021: ¥1280 (source: Ministry of Internal Affairs and Communications). Depending on the scenario, you may choose between 5 levels of prices from this average price to twice (+0 %; +10 %; +25 %; +50 %; +100 %):



Appendix C. Conditional logistic regression (clustered standard-error)

	Coefficient	Standard error
Status quo (<i>ASC.STATUS_QUO</i>)	-0.23***	0.07
Consumption quantity (<i>QUANTI</i>)	0.08	0.05
Substitution with catfish (<i>SUB.CATFISH</i>)	-0.09	0.07
Substitution with sanma (<i>SUB.SANMA</i>)	-0.02	0.06
Substitution with conger eel (<i>SUB.CONGEREEL</i>)	0.26***	0.05
No research development (<i>NO.RESEARCH</i>)	-0.27***	0.03
Increase awareness with a label (<i>AWAR.LAB</i>)	0.13***	0.04
Increase awareness with a campaign (<i>AWAR.CAMP</i>)	0.17***	0.04
Low increase in control of illegal trade (<i>ILLEGAL.LOW_INCR</i>)	0.09**	0.04
High increase in control of illegal trade (<i>ILLEGAL.HIGH_INCR</i>)	0.08**	0.03
Increase in the price of kabayaki (<i>COST</i>)	-0.001***	0.0004
AIC	14,073.01	
Number of respondents	1088	
Number of observations	19,584	

Note: ***significant at 1 %; **significant at 5 %; *significant at 10 %.

Appendix D. Latent class model estimates with three latent classes

Class preference	Class 1=1		Class 2=1		Class 3=1	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Status quo	-0.57***	0.14	0.61***	0.18	-2.07***	0.33
Consumption quantity	-0.18	0.10	0.07	0.16	0.53***	0.17
Substitution with catfish	0.63***	0.12	-0.58***	0.13	-0.98***	0.18
Substitution with sanma	1.37***	0.17	-0.98***	0.15	-2.18***	0.38
Substitution with conger eel	0.55***	0.1	-0.31**	0.13	0.29**	0.14
No research development	0.05	0.06	-0.34***	0.1	-0.91***	0.17
Increase awareness with a label	0.3***	0.08	-0.01	0.13	-0.001	0.13
Increase awareness with a campaign	0.23***	0.08	0.11	0.13	0.2	0.17
Low increase in control of illegal trade control	-0.13	0.09	0.18	0.11	0.26	0.17
High increase in control of illegal trade control	0.03	0.07	0.15	0.12	0.12	0.12
Increase in the price of kabayaki	-0.003***	0.0009	-0.004***	0.001	0.004***	0.002
Class membership						
Constant	0.37	0.33	-0.41	0.32		
AIC	12,840.88					
BIC	13,116.76					
Number of respondents	1088					
Number of observations	19,584					

Notes: Share1, Share2 and Share3 are conformable column vectors of membership model coefficients for classes 1, 2 and 3, with Share3 normalized to 0 for identification (<https://doi.org/10.1177/1536867x20931003>)

***significant at 1 %; **significant at 5 %; *significant at 10 %.

Appendix E. Post-estimation analysis of statistics of factors explaining class membership (N=1088)

	Sample	Class 1	Class 2	Test
Age <= 40	28 %	30 %	27 %	0.7573
Woman=1		42 %	44 %	0.698
Higher education=1		67 %	61 %	3.42*
Income < 4000,000 yen (Income > 4000,000 yen & Income < 8000,000 yen as reference)	45 %	46 %	43 %	0.426
Income ≥ 8000,000 yen (Income > 4000,000 yen & Income < 8000,000 yen as reference)	18 %	20 %	17 %	1.583
Live in rural area=1	38 %	34 %	45 %	11.37**
Know that the eel has the status of an endangered species=1	39 %	39 %	39 %	0.017
Know what constitutes an endangered species=1	66 %	72 %	63 %	6.989***
Avoid buying single-use products or products with plastic packaging =1	24 %	20 %	26 %	3.003*
Meat reduction=1	15 %	10 %	17 %	6.976***
Taste=1	63 %	68 %	61 %	3.75*
Culture=1	14 %	18 %	13 %	4.66**
Occasional consumer=1	37 %	36 %	31 %	2.888*
Score of NEP (<i>Limit to growth items</i>)	4.86			3.332*
Score of NEP (<i>Anti-anthropomorphism items</i>)	4.42			5.468**
Score of NEP (<i>Nature balance items</i>)	4.77			5.273**
Score of NEP (<i>Anti exceptionalism items</i>)	4.46			5.816**

(continued on next page)

(continued)

	Sample	Class 1	Class 2	Test
Score of NEP (<i>Ecological crisis items</i>)	4.84			5.816**
Score of All NEP <i>items</i>	4.67			7.637***
Total	1088	307	781	

Note: Chi Square Test for binary variables; Kruskal-Wallis test for ordinal variables (Score of NEP *items*)

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