Effect of Fishery Information Provision on Sustainable Consumption

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Abstract:

With the surge in global demand for seafood, although efforts are being made to guide fisheries and farmed aquaculture, which still rely on natural resources, toward sustainability, it is pertinent to guide people toward sustainable consumption patterns. We consider bluefin tuna, whose largest consumer is Japan and whose stock levels were at risk in the early 2010s, and examine whether consumers can be impelled to consume fish produced in a resource-conserving manner if they have adequate information on stock status and fishing methods. We explore the potential of fixed shore net fisheries and full-cycle aquaculture techniques, which have received limited attention in previous studies. Furthermore, we analyzed the effectiveness of ecolabels indicating that, in the case of natural products, no juvenile fish were caught, and in the case of farmed fish, no juveniles were used as seedlings or artificial seedlings were used. We conducted randomized controlled trial to analyze how information provision changes the marginal willingness to pay for fish commodity attributes. The analysis reveals that the information provision significantly and positively affects payments for bluefin tuna produced by resource-conserving fixed shore net fisheries and full-cycle aquaculture. Moreover, it significantly increases the premium for ecolabeling, suggesting the need to provide consumers with knowledge on resource status and fishing methods. However, as the effects of information provision are heterogeneous, new approaches such as consumer segmentation at the retail level are required to implement these efforts in society.

Keyword: sustainable fisheries; full-cycle aquaculture; ecolabeling; information provision; randomized controlled trial; choice experiment; consumer heterogeneities

Introduction

The increasing availability of protein sources in developing countries has increased global seafood consumption at an average annual rate of 3% since 1961, exceeding the population growth rate of 1.6% (FAO, 2022; Han et al., 2020). Half of this increase is attributed to population growth, while the other half depends on per capita consumption, which increased from 9.9 kg in the 1960s to 20.5 kg in 2019. Global economic development, improved preservation and transportation technologies, and changing dietary trends may increase seafood consumption by 15% over the next decade (FAO, 2022). In addition, climate change has significantly impacted the abundance and distribution of migratory fish stocks, causing various ocean governance issues (Pinsky et al., 2018; Pomeroy et al., 2016). In this context, establishing stable production and supply systems for marine resources is a global challenge.

Among the Sustainable Development Goals (SDGs), the 14th goal is to achieve a healthy and reproducible ocean through sustainable management and regulations (UN, 2015). The Fisheries Agency of Japan (FAJ) has established the implementation of fisheries resource management in response to changes in the marine environment as the first pillar of a new basic plan for fisheries (FAJ, 2022). The 12th goal of the SDGs also declares “to ensure sustainable patterns of production and consumption,” establishing that the sustainability of fishery resources depends not only on production methods but also on the consumer behavior (Wei et al., 2023).

Ecolabeling and food-labeling regulations can overcome this situation in the consumption phase (Hori et al., 2020; Kitano & Yamamoto, 2021). Giacomarra et al. (2021) review fish ecolabeling studies from a sustainability awareness perspective and argue that ecolabels promote sustainable fish consumption. Many studies suggest that consumers are willing to pay more for seafood products containing ecolabels such as Marine Stewardship Council (MSC) and Aquaculture Stewardship Council (ASC) (Ariji, 2010; Bronnmann & Asche, 2017; Bronnmann & Hoffmann, 2018; Chen et al., 2015; Kitano & Yamamoto, 2019; Phong et al., 2023; Uchida et al., 2013; Uchida et al., 2014). Additionally, many studies demonstrate that consumers pay premiums for environment-friendly products if provided with certain knowledge and information. However, few studies have made rigorous causal inferences addressing the endogeneity of individual attributes (including robustness checks) and have not examined changes in the distribution of individual premium payments.

Most studies on the effects of information provision suggest that consumers’ expanded knowledge of the state of marine resources and significance of ecolabels accelerates various ongoing environment-friendly initiatives (Cantillo et al., 2020; Saidi et al., 2023). In Japan, government surveys and past studies indicate that consumers have limited knowledge of seafood ecolabels (FAJ, 2024b; Hori et al., 2020). Specifically, appropriate information provision can improve consumers' responses to ecolabeling.

However, few studies have analyzed the impact of consumer perceptions of specific fishing (catch) methods on purchasing behavior (except for certification through third parties such as ecolabels). While purse seine fishing may increase resource pressure owing to the risk of bycatch of juvenile fish, fixed shore net fishing, a passive fishing method, poses less risk to the marine ecosystem (Gilman, 2011; Liu & So, 2024). Although the conservation of juvenile fish is important for biological recovery, to the best of our knowledge, only Zander and Feucht (2018) estimate consumers' willingness to pay in this regard. One reason for the lack of attention to fishing methods is that retailers are generally not (legally) obligated to display fishing method information to consumers. However, consumer awareness regarding fishing methods is important for a sustainable fish supply, as the pressure on stock levels depends on the fishing methods and rules used to produce fish products. Lack of awareness, due to long and stretched fish distribution channels and information asymmetries between producers and consumers, can lead to market failure (Dhaigude et al., 2021; Verbeke, 2005).

Several studies report the differences between wild and farmed products (e.g., legally required labeling in Japan). Many studies indicate that wild fish is preferred over farmed fish (Bronnmann & Asche 2017; Bronnmann & Hoffmann 2018; Davidson et al., 2012). Moreover, this study explores the possibility of full-cycle aquaculture of bluefin tuna. Ariji (2010) examines how information provision affects consumer behavior when full-cycle aquaculture is in its early stages of development. However, the effect of information provision is obscure because consumers are also in the early stages of awareness. It is likely that many Japanese consumers will be aware of full-cycle aquaculture technology after a decade, as market demand reportedly increases considering the SDGs (Kurokawa, 2023).[1]

We focus on the Japanese consumption of bluefin tuna because Japan is one of the largest consumers of fish in the world (Guillen et al., 2019). Among countries with more than 10 million inhabitants, Japan is the world's largest consumer of fish in 2021, consuming about 70 kcal per person per day, and is the third in

[1] However, the use of artificial seedlings is sluggish because the production technology is unstable and cost of artificial seedlings is relatively high compared with wild seedlings.

total supply after Indonesia and China (FAOSTAT).[2] In addition, as Japan is the world's largest bluefin tuna fishing country, consuming approximately 80% of the world's catch, it bears responsibility for the effective utilization of its resources (WWF Japan, 2021). In 2009, bluefin tuna stock levels reached a historic low, and rules for recovery are established through international organizations, such as the Regional Fisheries Management Organizations on tunas (FAJ, 2024a).[3] Controlling the catching of juvenile fish is an important factor in the future recovery of the stock (Sakiyama, 2017).

This study applies a choice experiment to analyze how the labeling of bluefin tuna (juvenile) resource conservation and information on various production methods affect consumers' purchasing behavior. Moreover, the experiment examines the impact of information provision on purchasing behavior. A randomized controlled trial (RCT) is conducted by randomly dividing the respondents into two groups, one with and one without information, to examine the effect of information provision from a causal perspective. The choice experiment estimates the marginal willingness to pay (MWTP) for bluefin tuna using product attributes such as fishing method, full-cycle aquaculture, and resource conservation ecolabeling. We also explore the distribution of individuals' willingness to pay, that is, consumer heterogeneities.

Materials and methods

Randomized control trial

We examine how information provision affects consumers' choice behavior. The gold standard for estimating the treatment effects of interventions (information provision) on subjects is RCTs (Pearce & Raman, 2014). We analyze how information provision changes the MWTP for fish commodity attributes. Specifically, we showed subjects illustrations of the differences between tuna farming using conventional wild seedlings and artificial seedlings (Appendix Figure 1) and fishing methods (purse seine fishing and fixed shore net fishing: Appendix Figure 2). Then, we informed that 1) increased production in aquaculture using wild seedlings involved risks to juvenile fish stocks, 2) the International Scientific Committee reported that the parent stock in 2014 was near its lowest level in the past 62 years and that the age-0 fish recruitment was at the 28% level

[2] Freshwater fish are excluded.
[3] The 2010 Convention on International Trade in Endangered Species of Wild Fauna and Flora proposed a ban on commercial trade in Atlantic bluefin tuna. In addition, Atlantic and Pacific bluefin tuna were listed as "Endangered" (2011) and "Vulnerable" (2014), respectively, on the Red List of the International Union for Conservation of Nature and Natural Resources (Yamamoto, 2016).

of the average for the past 62 years, and 3) the recovery and conservation of bluefin tuna stocks required not only the efforts of the producers but also the understanding of distributors and consumers.

Let $MWTP_{ki}$ be the MWTP for product attribute k of consumer i, and we estimate the difference between MWTP when information is provided (treated) and when it is not (untreated). Let $MWTP_{ik}^{T}$ be the potential outcomes with information and $MWTP_{ik}^{U}$ be those without information for the same subjects, the average treatment effect (ATE) is

$$ATE = E\left[MWTP_{ik}^{T} - MWTP_{ik}^{U}\right]. \quad (1)$$

However, this cannot be calculated because only one potential outcome can be observed. Therefore, we consider the difference (D) between the sample means ($\hat{E}()$) of the two groups as follows:

$$D = \hat{E}[MWTP_{ik}^{T}|T, \boldsymbol{X}] - \hat{E}\left[MWTP_{ik}^{U}|U, \boldsymbol{X}\right], \quad (2)$$

where the T and U conditions represent the actual treated and untreated groups, respectively, and $\boldsymbol{X}$ is represents other attributes of the subject that affect the outcome. Assuming that the treatment assignment is random and that a sufficiently large sample is available to benefit from the law of large numbers, $\boldsymbol{X}$ does not, on average, affect D through the presence or absence of treatment (orthogonality). Specifically, it asymptotically converges to the following equation:

$$D = \hat{E}[MWTP_{ik}^{T}|T] - \hat{E}\left[MWTP_{ik}^{U}|U\right]. \quad (3)$$

Here, $\hat{E}[MWTP_{ik}^{U}|T] = \hat{E}[MWTP_{ik}^{U}|U]\ and\ \hat{E}[MWTP_{ik}^{T}|T] = \hat{E}[MWTP_{ik}^{T}|U]$ also hold, which means that there is no selection bias. For the former (or latter), equation (3) is equivalent to

$$\hat{E}[MWTP_{ik}^{T}|T] - \hat{E}\left[MWTP_{ik}^{U}|T\right] = \hat{E}\left[MWTP_{ik}^{T} - MWTP_{ik}^{U}|T\right] = ATE. \quad (4)$$

The second equation in (4) is called the average treatment effect on the treated (or the average treatment effect on the untreated if the latter is used), which is also equal to the ATE in the case of an RCT.

However, in equation (3), if the randomization is insufficient (some subject attributes are confounding factors), the ATE contains a selection bias. Hence, we also estimate causal effects using the inverse probability weighting (IPW) methods to overcome this problem and for robustness checks (Imbens & Rubin, 2015).

Choice experiment

We provided three product choices to the respondents and asked them to choose the product they would purchase. All products were standardized to 100g medium fatty (chu-toro) tuna. The attributes of the evaluated products were production (fishing or farming) method, place of origin (imported or domestic), preservation method (fresh or frozen), serving method (block or sashimi), resource conservation labels, and price. All product attributes that consumers consider important when purchasing tuna products were considered, except for fish parts and expiration dates, which were fixed.[4] The respondents were informed that the resource conservation label was a hypothetical label that sellers could use voluntarily if, in the case of wild caught tuna, tuna was not a juvenile (under 3 years old) or spawning parent fish, or if, in the case of farmed tuna, seedlings (fish) initially introduced into fish tanks were not juveniles or artificial seedlings were being used.[5] Table 1 lists the levels of attributes used.

Using these attributes, product profiles were determined using an orthogonal array for robust point estimates, effectuating a final set of 24 profiles. The respondents were asked to choose one of three options: two commodity profiles (100g) and “no purchase.” This question was repeated six times for each respondent. By further dividing the respondents into two groups, we conducted an experiment with two profiles (choices) × six times (questions) × two groups = 24 profiles.

We assume the following random utility model, where i is an individual, j is an alternative, and t is a choice opportunity (McFadden, 1973):

$$U_{ijt} = \boldsymbol{X}_{ijt}^{\intercal}\beta_i + e_{ijt},$$

where e_{ijt} is the unobservable error term and is assumed to follow a Gumbel distribution; if K is the number of observed commodity attributes, then X_{ijt} is a $K \times 1$ vector representing the commodity attributes when individual i faces option j on opportunity t; β_i is the utility parameter for individual i that cannot be observed. We use the random parameter logit (RPL) model (McFadden & Train, 2000), where β_i follows a continuous density function and varies across individuals in the population. Panel data are used for this model (multiple-choice situations per individual are available) because t in the above equation represents multiple-choice opportunities for the same respondent. Denoting y_{ijt} as a dummy equal to 1 if i chooses alternative j for opportunity t, the joint probabilities (series of choices) for individual i can be

[4] These are, respectively, because 1) consumers perceive products with different parts as different products and prices differ significantly, and 2) blocks and sashimi are basically consumed on the day they are bought.

[5] The label shown in Appendix Figure 3 was presented to the respondents.

expressed as

$$P_i = \prod_t \prod_j \frac{\sum_j y_{ijt} \cdot e^{X_{ijt}^T \beta_i}}{\sum_j e^{X_{ijt}^T \beta_i}}.$$

Using simulations, we can obtain the posterior distribution of the individual parameters (Croissant, 2020; Greene, 2020; Train, 2009). Hence, the heterogeneity of the individual parameters can be examined.

Data

An experiment was conducted with Japanese consumers using a web-based survey.[6] The survey was conducted in November 2017, and 930 valid responses were obtained (472 and 458 for the treated and untreated groups, respectively). The population assumed in the survey comprised households across Japan and the respondents were adults. The respondents were screened for household members who primarily purchased fresh food products at home. This was because, without limitations, the sample would include many respondents who did not purchase fresh food, making it difficult to ensure household representativeness (Cantillo et al., 2020).

Descriptive statistics for the socioeconomic attributes of the respondents are presented in Table 2. Owing to screening, there were more female respondents.[7] The average age of the respondents was approximately 46 years, which is slightly older than the average age of Japanese workers, that is, 44. The average household income of respondents was 6.52 million yen, which is approximately similar to the average household income of 6.53 million yen in 2017, excluding households with only elderly members (Ministry of Health, Labour and Welfare of Japan: MHLW, 2022). The right-hand side of Table 2 compares the mean values of the attributes between the treated and untreated groups. Randomization worked well, as no significant differences existed for either attribute in the 10% significance level test.

Figure 1 shows the product attributes that are ranked first to third in importance by the respondents when purchasing bluefin tuna. All these attributes were included in the choice experiment, except for the part and date (which were fixed in the experiment). The most important attribute is price, followed by the provision method (cut). The production method (method) is also important to many respondents and may be

[6] We used the services of NTT Com Online Marketing Solutions, Inc. a survey service company with more than 8 million monitors. See https://www.nttcoms.com/.
[7] According to the National Supermarket Association of Japan (NSAJ), women are more likely to purchase fish products at 87.2% compared with 55.5% for men (NSAJ, 2015).

sensitive to the difference between wild caught and farmed fish (Kitano & Yamamoto, 2020).

Results and Discussion

Estimation results

Table 3 presents the estimation results of the RPL models for the three sample groups (all respondents, respondents without information, and respondents with information). In all the models, the coefficient of price (*PRICE*) is negative, indicating that the results are reasonable with respect to the price attribute (negative marginal utility). The estimation results for the entire sample show that artificial seedlings (*ARTIF*) have a negative effect on choice probability, meaning that consumers are, on average, resistant to them. However, products with resource conservation labels (*LABEL*) generally increase the choice probability. This result is consistent with previous studies (Uchida et al., 2013; Uchida et al., 2014; Kitano & Yamamoto, 2020). The domestic and fresh products (*DOMES* and *FRESH*, respectively) increase the choice probability for all samples. Similar results have been reported in previous studies on various fish species in many countries (Alam & Alfnes, 2020; Ankamah-Yeboah et al., 2019; Ariji, 2010; Bronnmann & Asche 2017; Bronnmann & Hoffmann 2018; Davidson et al., 2012; Kitano & Yamamoto, 2021).

Remarkable changes due to information provision are those in choice probabilities regarding production methods and resource conservation labels. For artificial seedlings (*ARTIF*), the marginal effect of choice probability without information was significantly negative at the 10% level, whereas with information, it was nonsignificant, and the coefficient values decreased significantly. For the fixed shore net fishery (*FIXED*), the choice probability, which was nonsignificant without information, became significant at the 5% level when information was provided. Furthermore, the effect of resource conservation labels (*LABEL*) on choice probability was not observed in the absence of information, whereas it significantly increased the choice probability with information provision. These results indicate that information provision stimulates resource-conservation-oriented purchasing behavior.

Willingness to pay

After deriving the MWTP from the marginal effect of each attribute on choice probability, we examine the effect of the treatment (information provision). The MWTP is calculated by dividing the coefficient of each attribute k by the price coefficient as follows:

$$MWTP = -\frac{\beta_k}{\beta_{PRICE}}.$$

Whether the price parameter should be random is a controversial question. In most existing studies that have applied RPL, the coefficient of the price variable comprises only the mean value, and the standard deviation is fixed at 0. We also assume that the price parameter is fixed (Ankamah-Yeboah et al., 2019; Bronnmann & Asche, 2017; Bronnmann & Hoffmann, 2018; Kitano and Yamamoto, 2021). The MWTP of the alternative-specific constant (*ASC*) is approximately 1475 yen ($= -5.9/-0.004$) for all samples, which is generally consistent with the market situation for bluefin tuna in Japan.[8]

Figure 2 shows the MWTP estimates for each sample group, with attributes not achieving significance being transparent. Artificial seedlings (*ARTIF*) showed an additional negative willingness to pay of more than 50 yen for purse seine fishing (base level) in the untreated group; however, the negative willingness to pay may have been mitigated when information was given, although it was nonsignificant. In the no information case, the fixed shore net fishery (*FIXED*) was not significantly different from purse seine fishing, whereas when information was provided, it had a significantly higher MWTP of approximately 50 yen. Information provision influenced consumer preferences for fishing methods, particularly by increasing willingness to pay for resource conservation methods.

Furthermore, the resource conservation label (*LABEL*) with information shows more than twice the MWTP compared with no information (although nonsignificantly). These results are consistent with Uchida et al. (2013) and Uchida et al. (2014), who observe more than twice MWTP through information provision for salmon in Japan, and Ankamah-Yeboah et al. (2019), who find information provision approximately double the MWTP for trout in Denmark. Meanwhile, the results differ from those of Ariji (2010), who examines tuna in Japan and observes almost no effect of information provision. This may be because farmed salmon products (targeted by Uchida et al., 2013) are recognized and accepted by Japanese consumers at an early stage (the 2000s); however, the issue of tuna resource management was hardly recognized in 2010. Since 2010, there have been many reports on tuna resource management issues in Japan, and production methods that contribute to resource conservation, such as those developed by Kindai University, have

8 Yamamoto & Kitano (2017) investigated the retail price of bluefin tuna in Japan and estimated it to be between 980 and 1,280 yen. It is reasonable that the WTP, or reservation price, for the base profile of bluefin tuna in this study is on average distributed above the market price.

attracted considerable attention (Kurokawa, 2023). Therefore, it is possible that the ATE of information provision changed over time for the Japanese population.

The respondents in both the treated and untreated groups had high MWTP values for both domestically produced and fresh products (*DOMES* and *FRESH*). Prior studies suggest that the Japanese population strongly trusts domestic products for diverse foods and emphasizes on freshness (Aizaki et al., 2012; Aoki et al., 2017; Kitano & Yamamoto, 2019; Oishi et al., 2010). However, information provision significantly reduces the MWTP of *DOMES*. Assuming that consumers are budget constrained, information treatment increases the premium for resource conservation while lowering the relative willingness to pay for domestically produced attributes.

Heterogeneous treatment effect and robustness check

Here, we discuss the heterogeneity of the information treatment effect by exploring how the distribution of the MWTP changes with information provision. Furthermore, we verify the robustness of the estimation results.

Figure 3 shows the results of the kernel density estimation of the distribution of the estimated MWTP (individual parameters) for the three attributes related to resource conservation–*LABEL*, *AIRTIF,* and *FIXED*–separately with and without information provision. The mode of both distributions moves in a positive direction and their mean (dashed line) moves to the right, indicating that information provision leads, on average, to resource management-oriented consumer behavior. However, the variance of all distributions is larger when information is provided, indicating that the effect of information treatment differs across individuals. In particular, the distributions with information are flatter than those without information for *LABEL* and *AIRTIF*, indicating greater heterogeneity in the effects of the information treatment.[9]

Next, we verify the robustness of the estimation results. Differences in the mean values of the estimated individual parameters between the treated and untreated groups were tested. This simple comparison assumes that the information treatments are well-randomized using the RCT procedure. The results are shown in the left column of Table 4. The mean values of the individual parameters are significantly different at the 1% level for all attributes except *FRESH* (at the 10% level for fresh).

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[9] Feucht & Zander (2015) show that some consumers do not demand additional information about aquaculture, thus arguing that the challenge is how to provide such information.

Concerned with a case in which the RCT did not work, we estimated the ATE by IPW method using the main individual attributes as covariates. Figure 4 compares the unadjusted and adjusted propensity scores (distance) and covariates. The propensity score, *INC*, and *FFPU* exceeded the threshold of 0.1 before adjustment; however, the balance improved after adjustment. The ATE estimated using the IPW method is shown in the right-hand column of Table 5 and is almost identical to the RCT results, indicating the robustness of the estimated results.

Policy implication, limitation, and concluding remarks

We applied an experimental approach to test whether resource conservation fishing methods and labeling encourage resource-conscious consumer behavior through information provision. Our results indicate that consumer demand for tuna products produced by fixed shore net fishing, an ecosystem-friendly fishing method, and full-cycle aquaculture, in which all processes are under human control, can be stimulated by providing appropriate information. The fixed shore net fishery is a sustainable fishing method that has been practiced for hundreds of years; the FAJ is also working with the private sector to develop technology for releasing juvenile bluefin tuna that have entered fixed shore net fisheries (FAJ, 2018). Additionally, fixed-net fisheries have the advantage of being close to land, providing a year-round supply of fresh fish and a source of successors to the fishing industry. In Japan, the low birthrate and aging population have led to a serious shortage of primary industry workers, especially young people; therefore, promoting fisheries through fixed shore net fishing has advantages in terms of securing labor.

Initially, Japanese consumers avoided full-cycle aquaculture tuna because of their preference for wild products; however, its supply may increase in the future through technical improvements and consumer awareness (Masuma, 2016; Matsuno et al., 2010). The FAJ has established a council for the promotion of tuna farming and is developing a plan to expand the market for full-cycle farmed bluefin tuna (FAJ, 2020). Furthermore, consumers showed a positive willingness to pay for ecolabels, indicating resource conservation, by providing information on the status of marine resources. A limitation of this study is that in some cases (with or without information), the MWTP was nonsignificant for these resource conservation attributes. These results need to be verified using a larger sample.

The prosocial consumer responses to these fishing practices and ecolabels can only be achieved through proper education and information to consumers. Several schemes for fishery ecolabels, such as MSC, ASC, and Marin Eco-Label Japan (MEL), have been implemented in Japan but have not achieved sufficient results (Swartz et al., 2017). This may be owing to insufficient consumer awareness of ecolabels (approximately 11% of consumers) and fish stock status (FAJ, 2024b).

Although the FAJ has implemented projects to promote the increased consumption of sustainable seafood, they are biased toward direct support on the production side, and few promote an accurate knowledge-based understanding of seafood production on the consumption side (FAJ, 2023). Efforts are required to promote understanding of the current state of marine resources and emerging technologies through education and information nudging to achieve a sustainable fish supply system.

Another implication is that the effect of information provision is heterogeneous. Information provision increases consumers' MWTP, on average, but the effect varies significantly among consumers. Specifically, some consumer groups change their behavior in a prosocial manner, whereas others do not, even after information is provided. Therefore, in the retail stage, appropriate consumer segmentation and corresponding sales strategies are necessary to obtain effective marketing results. These aspects should be considered in future studies.

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Competing interests

The authors declare no conflict of interest in the preparation of this paper.

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Tables and Figures

Table 1 Attributes and Levels for Choice Experiments

Attributes	Levels				
Farming/ fishing method	Artificial seed farming (*AIRTF*)			Wild seed farming (*WILDF*)	
	Fixed shore net (*FIXED*)			Purse seine fishery (base)	
Origin	Imported (base)			Domestic (*DOMES*)	
Preservation method	Frozen (base)			Fresh (*FRESH*)	
Providing method	Block (base)			Sashimi (*SASHI*)	
Label	No (base)			Yes (*LABEL*)	
Price (*PRICE*: yen/100g)	680	880	980	1280	1480

Table 2 Descriptive statistics

	All		Untreated group		Treated group		t-test
	Mean	SD	Mean	SD	Mean	SD	p-val
1 if respondent is a female; 0 otherwise: *FEM*	0.59	0.49	0.61	0.49	0.57	0.5	0.157
Age of respondents: *AGE*	46.43	13.86	46.2	14.04	46.66	13.68	0.613
1 if respondent is married; 0 otherwise: *MAR*	0.60	0.49	0.59	0.49	0.61	0.49	0.437
Number of family members: *FAMI*	2.48	1.16	2.49	1.12	2.48	1.2	0.916
Number of family members under 12 years: *CHIL*	0.24	0.56	0.24	0.56	0.24	0.57	0.832
Family income of respondent (million yen/year): *INC*	651.75	352.24	632.78	345.5	670.17	358.06	0.106
Frequency of fresh food purchases per week: *FFPU*	3.34	1.82	3.24	1.78	3.43	1.85	0.116
n	930		458		472		

Note: The t-test shows the results of the test of means between the treatment and control groups.

Table 3 Estimation results of RPL models

	Whole sample				Without information (Untreated)				With information (Treated)			
	Mean		SD		Mean		SD		Mean		SD	
	Coef.	s.e.	Coef.	s.e.	Coef.	s.e.	Coef.	s.e.	Coef.	s.e.	Coef.	s.e.
ASC	5.908***	0.234	2.576***	0.128	5.954***	0.319	2.234***	0.162	5.855***	0.345	2.589***	0.180
ARTIF	-0.186**	0.083	0.252*	0.144	-0.226*	0.118	0.150	0.209	-0.128	0.117	0.374**	0.188
WILDF	-0.022	0.081	0.032	0.135	-0.052	0.115	0.145	0.208	0.046	0.115	0.146	0.223
FIXED	0.105	0.076	0.602***	0.118	0.012	0.108	0.566***	0.167	0.214**	0.107	0.726***	0.162
DOMES	1.356***	0.067	0.981***	0.099	1.363***	0.092	0.835***	0.145	1.312***	0.097	0.872***	0.138
FRESH	0.690***	0.056	0.505***	0.107	0.660***	0.077	0.458***	0.155	0.724***	0.081	0.400**	0.156
SASHI	0.039	0.046	0.620***	0.085	-0.011	0.063	0.596***	0.122	0.094	0.067	0.690***	0.124
LABEL	0.215***	0.062	0.065	0.131	0.130	0.088	0.094	0.197	0.308***	0.089	0.381**	0.155
PRICE	-0.004***	0.000			-0.004***	0.000			-0.004***	0.000		
LL	-4625.8				-2263.0				-2354.4			
AIC	9285.7				4559.9				4742.9			
Pseudo R^2	0.164				0.162				0.169			
Obs.	5580				2748				2832			

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Random parameters other than "PRICE" are assumed to be normally distributed.

Table 4 ATEs estimated by RCT and IPW for robustness check

	RCT		IPW		
	diff	p-val	coef.	s.e.	p-val
AIRTF	24.598***	0.000	24.532***	1.744	0.000
WILDF	23.363***	0.000	23.373***	0.746	0.000
FIXED	45.164***	0.000	44.488***	5.145	0.000
DOMES	-28.075***	0.000	-27.978***	7.482	0.000
FRESH	5.294*	0.066	4.957*	2.881	0.086
SASHI	25.344***	0.000	24.208***	5.206	0.000
LABEL	39.227***	0.000	39.070***	1.731	0.000

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

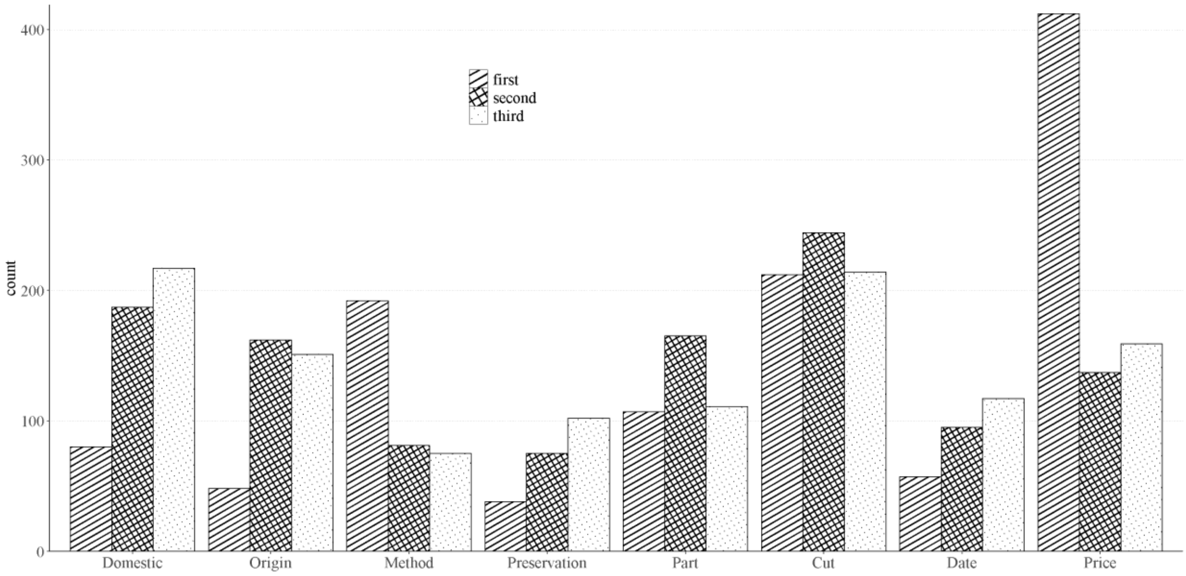


Figure 1. Bluefin tuna purchasing criteria.

Note: The respondents were asked to pick the “first” to “third” most important purchase criteria.
The vertical axis indicates the count of responses for each criterion.

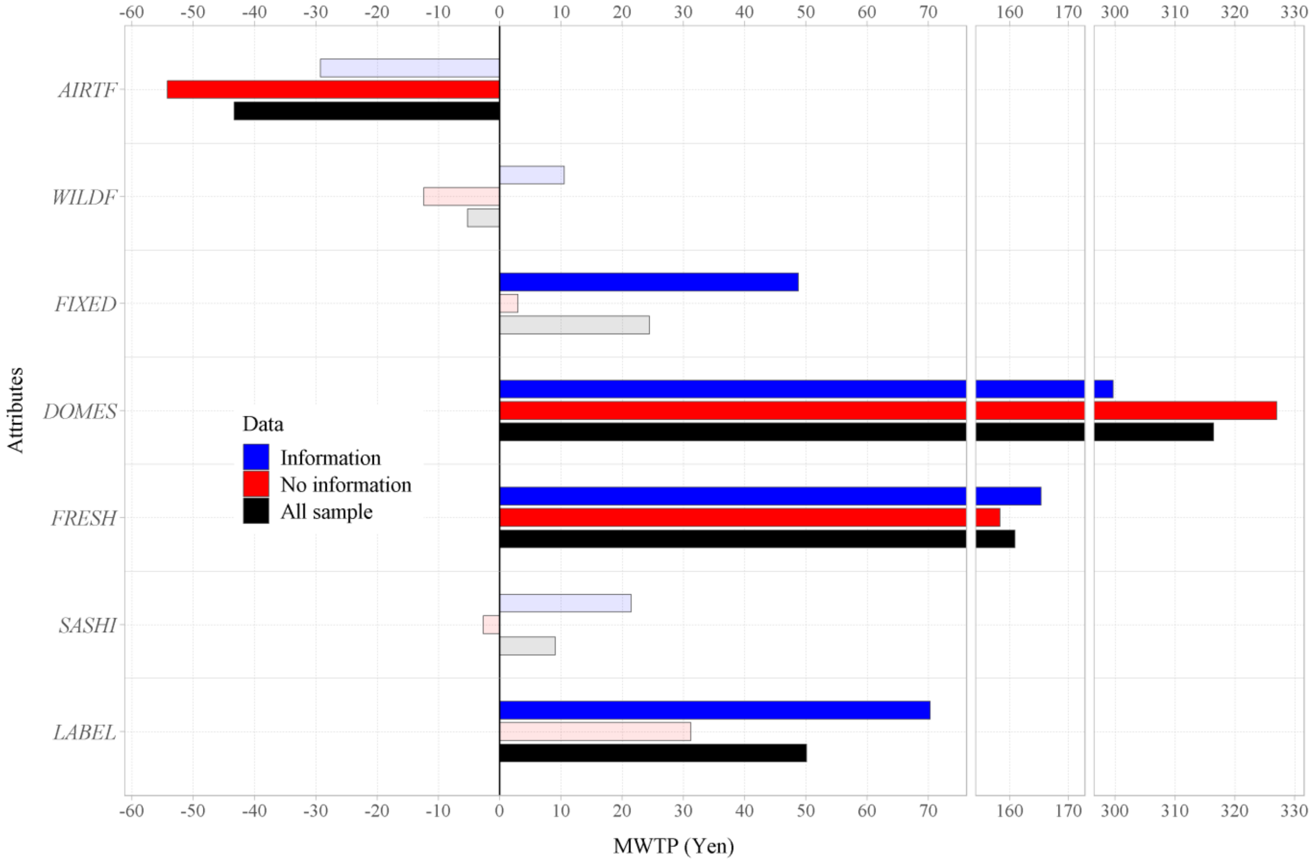


Figure 2. Comparison of MWTP estimates for each attribute across samples.

Note: Transparent bars indicate statistically nonsignificant attributes.

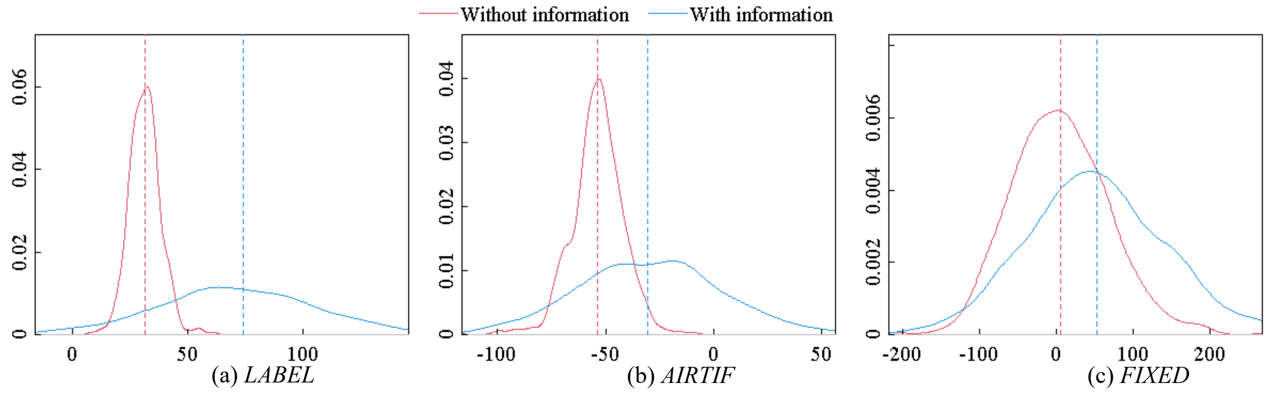


Figure 3. MWTP change and heterogeneous effects of information treatment

Note: The dotted line indicates the mean of each distribution.

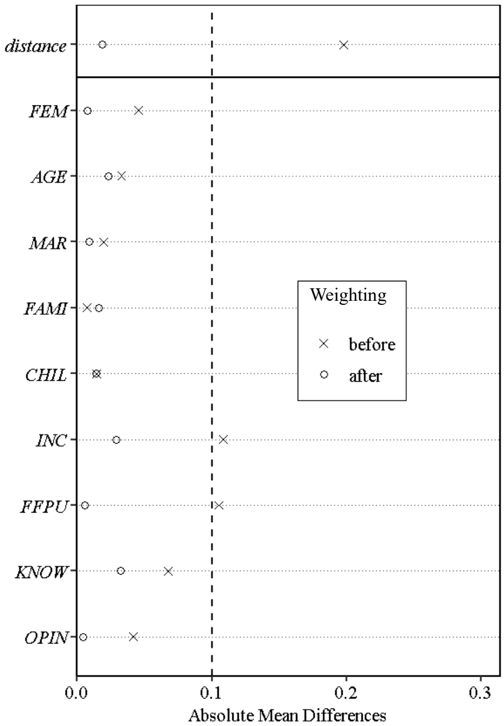
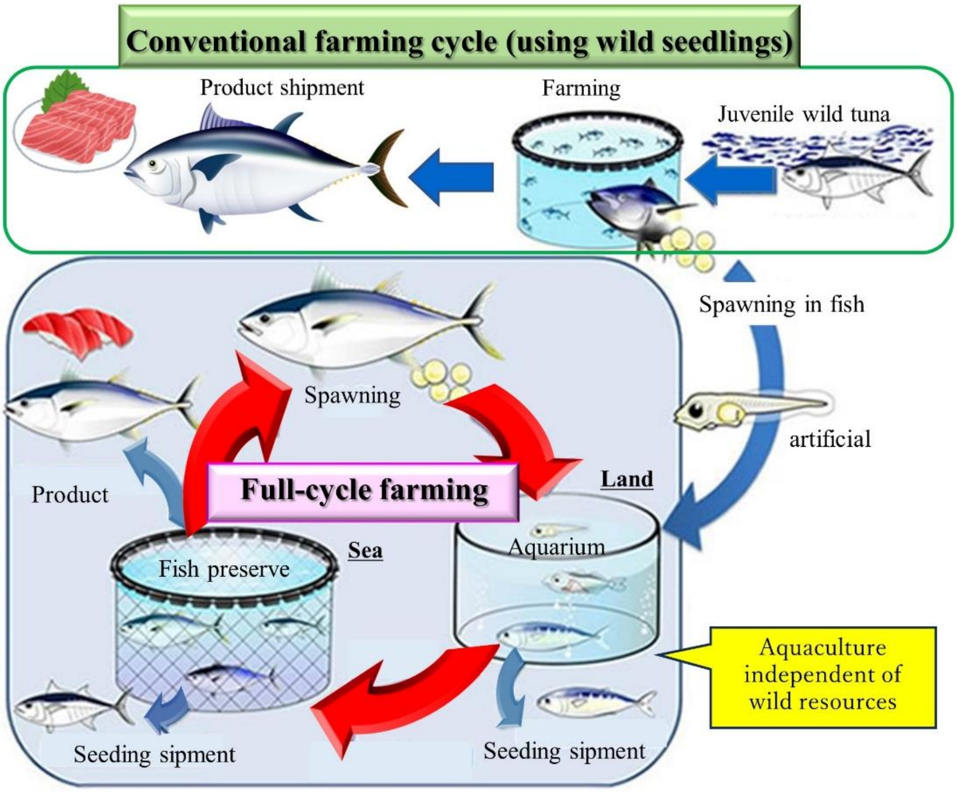


Figure 4. Covariate balance measured by ASMD.

Note: “distance” means the difference between before and after inverse probability weighting. The dotted line shows an ASMD, which is the typical threshold.

Supplementary Material

Appendix Figures

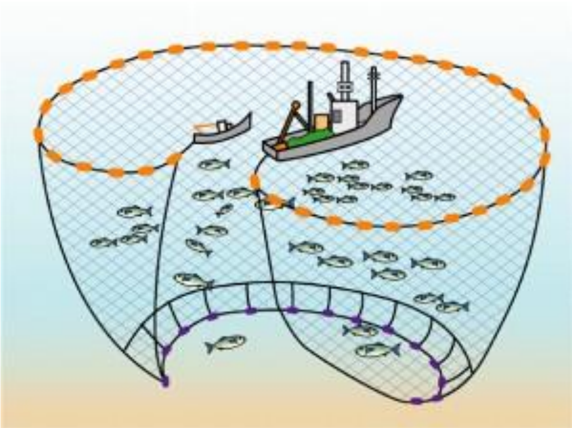


Appendix Figure 1 Illustration of the cycle of aquaculture with wild and artificial seedlings

Note: Modified from materials provided by the Fisheries Laboratory, Kindai University.

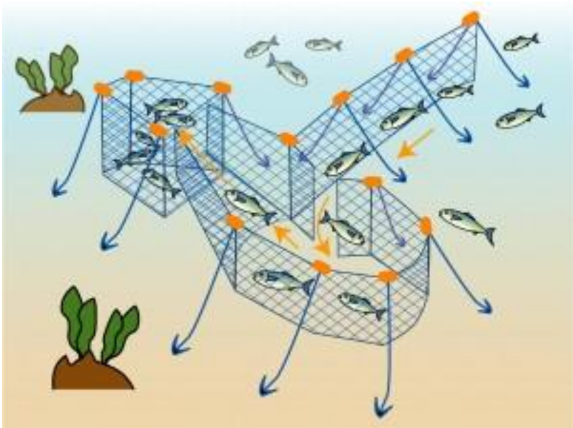
Purse seine fishery

Searching for schools (mixed with spawners and immatures) and capturing large numbers of fish



Fixed shore net fishery

Species, size, and quantity of fish to be caught depend on resource conditions



Appendix Figure 2 Illustration of fishing methods

Source: Hamada city, Japan: https://www.city.hamada.shimane.jp/www/contents/1001000002239/index.html

Appendix Figure 3 Illustration of resource conservation label