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Consumer Preferences for the Provision of Water Quality Services by Oysters

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ABSTRACT

When Does Public Information Undermine the Efficiency of Reverse Auctions for the Purchase of Ecosystem Services?

Keywords: experimental economics, revealed preferences, dichotomous choice, eco-system services, oysters, willingness to pay

In the United States and many other countries around the world, estuary eutrophication is a major environmental problem that can result in harmful algal blooms with detrimental impacts on eco-systems and humans, while imposing substantial costs. Oysters are suspension feeders, filtering phytoplankton from water anad thereby reducing organic matter, the primary driver of eutrophication. The U.D. National Oceanic and Atmospheric Administration (NOAA) supports using shellfish aquaculture as a nutrient management practice. Our revealed preference dichotomous choice experiments test if participants are willing to pay price premiums for oysters that provide eco-system services. Results suggest that if oysters are from waters containing an unknown amount of nutrients, providing participants with information does not have an effect. However, providing partcipants with information about eutrophication and oysters' ability to filter nutrients from water makes them more likely to choose oysters from low nutrient waters. Oysters from moderate and high nutrient waters, which provide larger eco-system services, are significantly more likely to be selected if participants receive no information.

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1. Introduction

According to the United States Environmental Protection Agency (EPA), "Nutrient pollution … is one of America's most widespread, costly and challenging environmental problems…" (EPA 2015). Howarth et al. (2002) argue that 60% of coastal rivers and bays in the United States have been moderately to severely degraded by eutrophication. In the United States, the mid-Atlantic estuaries are the most impaired by eutrophication (Bricker 2007, see also Driscoll et al. 2003), leading to overgrowth of algae, which reduces the amount of oxygen in the water supply, which, in turn, results in damages to plant and animal life. Consequently, eutrophication is associated with substantial economic impacts (Smith and Schindler 2009). Dodds et al. 2009 estimate that annual value losses related to decreases in recreational use, real estate, recovery efforts to aid endangered species, and drinking water are approximately $2.2 billion. Similarly, Smith and Schindler (2009) state that the annual cost of eutrophication in the United States are likely billions of dollars (see also Anderson et al. 2000). Additionally, Dolah et al. (2001) point to the economic impacts of health care related costs linked to harmful algal blooms (see also Hoagland et al. 2002 and Graneli and Turner 2006) while Palm-Forster et al. (2015) analyze the welfare loss associated beach closures. Moreover, these problems are not confined to the United States but similar impacts are reported in Europe and China (Camargo and Alonso 2006, Leone et al. 2007, Giles 2005, Kronvang et al. 2008, Leone et al. 2009, Woodward et al. 2009, Le et al. 2010).

One possible way to manage nutrient pollution involves using shellfish aquaculture, such as oysters, that feed on phytoplankton. Oysters are suspension feeders and by consuming phytoplankton they reduce the organic matter that create eutrophication (Kirby and Miller

2005). The United States National Oceanic and Atmospheric Administration (NOAA) supports using shellfish aquaculture for, "… *nutrient removal and eutrophication removal*" (NCCOS 2015). Oyster aquaculture is versatile. Oysters are a renewable and consumable private good and they provide ecosystem services, a public good, mostly by filtering phytoplankton, the primary driver of eutrophication, from estuaries and other water bodies. Additionally, Rose et al. (2014) show that oyster aquaculture may outperform other commonly applied best management practices for nitrogen removal on a per-acre basis. Additionally, Rose et al. (2014) note that using oysters may be a cost-effective best management tool.

In the Chesapeake and Delaware Bay oyster numbers have declined by 90-99% compared to historic populations due to disease and overfishing, while, globally, 85% of oyster reefs have been lost (Beck et al. 2009). The NOAA Chesapeake Bay office estimates that oysters were once able to filter the entire water of the Chesapeake Bay in one week, providing a substantial public service (NOAA 2015). In Delaware, currently the only East Coast State without active oyster aquaculture, House Bill 160 was signed in August 2013 to permit oyster aquaculture in the Inland Bays by leasing areas to private persons. A major concern for private investment is that the market price for oysters may understates its true value and, thus, leads to underinvestment and, consequently, under-provision of ecosystem services (Pigou, 1924).

A solution lies in the increasingly popular markets for local environmentally friendly goods called 'green markets.' Products demanded on green markets are referred to as 'green products' (a.k.a. impure public good) as they display characteristics of both a public and a private good and provide a means through which these goods can be provided privately, resulting in increased social welfare (Vandermerwe and Oliff 1990; Ferraro et al. 2005, Kotchen 2006). The expansion of green markets is largely due to consumers' willingness to pay price premiums for goods that exhibit environmental benefits. Examples of green products are electricity generated by renewable energy, eco-tourism, organic produce, and shade-grown coffee (Ferraro et al. 2005, Kotchen 2006). Laroche et al. (2001) report on an increasingly environmentally conscious market place and findings by Coddington (1990) indicate that in 67% of Americans stated they were willing to pay 5-10% more for an environmentally friendly goods. On the other hand, in order for oysters to filter phytoplankton from water they have to be immersed in the nutrient-polluted water until they have reached marketable size, then harvest (thereby removing the nutrients from the water body) and sold for consumption. Hence, oysters are a special kind of "green" commodity. Whereas, shade grown coffee appears to be as "clean" as other types of coffee, oysters maybe perceived as less "clean" if they come from waters that suffer from eutrophication and could induce disgust or contamination fears in consumers. Kecinski et al. (2015a and 2015b) show that even when consumption of an item does not increase the associated risk, people may shun the item simply because it has previously come into contact with a "contaminant" (see also Rozin et al. 1985, 1986 and Rozin 2001). While there the economic literature involving oysters is limited, Bruner et al. (2014) use an experimental auction market to measure consumer's willingness to pay for traditional raw oysters versus postharvest-processed raw oysters. While postharvest-process reduces the health risks associated with eating raw seafood, the authors showed that consumers pay more for traditional raw oysters than they do for postharvest-processed raw oysters. Dedah et al. (2011) look that the impacts of oyster demand and warning labels about serious illness and death among in people with liver disease, chronic illness and weakened immune systems. The authors find that warning labels about these health risks have reduce demand in oysters from the Chesapeake and Gulf region but increase demand for oysters from the Pacific region and foreign oysters.

However, consumers' willingness-to-pay (WTP) for eco-system services provided by oysters, has not been studied before. Based on previous findings related to "green market" one might assume that oysters might fetch a price premium in the market. On the other hand, considering the existing literature on disgust, one might expect that consumers react rather sensitively to oysters from water bodies that suffer from eutrophication. Motivated by this lack of knowledge, we design revealed preferences dichotomous choice experiments to test if oyster consumers are willing to pay price premiums for oysters that provide eco-system services. Providing participants with different information in three treatments, suggests that overall participants pay higher prices for oysters if they receiving information about oysters ability to filter water and the nutrient-level of the water the oysters were harvested from. Furthermore, we find that participants are more likely to buy oysters from waters suffering from eutrophication in our baseline treatment. The more information participants receive about oysters ability to filter water and the eutrophication problems, the more likely participants become to purchase oysters form low-nutrient waters. The article is structured in the following manner: Section 2 discussed the research method, sampling locations, and oysters used in the experiments; section 3 presents the results and section 4 concludes the article with a summary.

2. Experimental Design

Our experiments consist of a simple dichotomous choice design. Dichotomous choice experiments, also known as posted-price experiments, have a binary decision structure – yes/no, on/off, 1/0, etc. In that sense, participants either agree to purchase a certain good, or alternatively, agree to perform a certain task, at a posted price. Wu et al. 2014 have previously shown that dichotomous choice designs may provide more realistic willingness-to-pay estimates than an auction design and the Becker-Degroot-Marschak (BDM) (Becker et al. 1964) mechanism as willingness-to-pay estimates were significantly lower for the dichotomous choice setting compared to a second price auction and BDM. Additionally, Arrow et al. 1993 recommend the use of dichotomous choice questions as they provide closer a real-life decision situation, "… as occurs with most real referenda." Participants in the experiments were asked to make simple Yes/No decisions on whether or not they wanted to purchase a certain type and amount of oysters at a randomly determined and posted price. If they decided "Yes", they agreed to purchase these oysters at the posted price. If they decided "No", they did not agree to purchase these oysters at the posted price. At the end of the experiment one decision was randomly selected and implemented.

Before the start of the experiment participants were told that they would receive $10 from the experimenters and that they may think of this money as being in a bank account from which they can withdraw money to purchase oysters. If the randomly selected decision at the end of the experiment indicated that the participant decided "No" to purchasing the oysters at the posted price, the experimenters would simply hand them $10 at the end of the experiment. In case the randomly selected decision revealed that they decided "Yes" to purchasing the oysters at the posted price, then, the price of the oysters would be subtracted from the $10 in their account, and the participant received the remainder plus the oysters. In case the oysters cost $0 they would receive the oysters and the $10. In case the price of the oysters was higher than the account balance of $10, participants would have to use their personal funds to pay for the difference (cash, checks and credit cards were accepted) – this point was stressed several times in the instructions and also on the consent form.

Before participants made their decisions, they had to decide how many oysters they would want to purchase in the experiment. Typically, oysters are sold in dozen or half dozen (restaurant quantities), however, in order to give participants more choices we decided to offer oysters in bundles of three – 3, 6, 9 and 12. Oyster prices were shown as a 'per oyster price' as well as a total price depending on the number of oysters the participant had indicated they would want to purchase. The price listed for every purchasing decision was randomly drawn from a normal distribution with a mean of $1.50 and standard deviation of $0.50. These randomly generated 'per oyster' prices fit well with existing market prices at restaurants and retail stores in the United States. Participants made a total of eight purchasing decisions, out of which one was randomly selected for implementation at the end of the experiment.

Four Oysters. In order to address our central research questions concerning if and under what circumstances participants are willing to pay price premiums for the provision of ecosystem services provided by oysters, each purchasing decision involved a particular type of oyster that was harvested from a body of water that contained a certain level of nutrients, as reported by the National Estuarine Eutrophication Assessment Update (Bricker et al. 2007) of the United States National Oceanic and Atmospheric Administration (NOAA).

In total there were four different types of oysters:

N1. Oysters from a location with unknown levels of nutrients

N2. Oysters from a location with low levels of nutrients

N3. Oysters from a location with moderate levels of nutrients

N4. Oysters from a location with high levels of nutrients

Eutrophication threatens the health of many estuarine systems and Coastal zones, which are among the most productive ecosystems in the world (Agardy 1997). Excess of nutrients causes harm in many coastal ecosystems in the United States and presents a major marine resource-management problem (Driscoll et al. 2003, Rose et al. 2014). Given oysters ability to filter nutrients from water, their use in the removal of nutrients has previously been proposed (see Newell 2004, Lindahl et al. 2005, Lindahl 2011, Kellogg et al. 2013). However, previous research has not addressed if consumers have preferences to pay price premiums for these services. If consumers were to show these types of preferences, it would signal farmers and potential farmers that investments into oyster aquaculture in estuaries suffering from eutrophication does not only provide an environmental incentive but it may also be more profitable. At the same time it would provide policy makers with evidence based information on the profitability of establishing areas for aquaculture in estuaries impacted by nutrient pollution, which yield ecosystem services as well as provide local economies with income. On the other hand, if participants have negative reaction to oysters from high nutrient waters, suppliers may want to avoid certain product labeling to mitigate potential stigma. Moreover, Rose et al. (2014) reports that oyster aquaculture may be a cost-effective best management practice and should be integrated into a comprehensive plan to control nutrient pollution. The level of nutrients in the water from which the oysters were harvested was the only information shared with all participants. Oysters from a location with unknown nutrient levels came from Tomales Bay, California; Oysters from a location with low nutrient levels came from Willapa Bay, Washington; Oysters from a location with moderate nutrient levels came from Chincoteague Bay, Virginia; and Oysters from a location with high nutrient levels came from Long Island Sound, New York. Each participant made two decisions for each type of oyster as distinguished by the nutrients in the water they were harvest from.

Three Treatments. In order to understand how information about nutrients, excess amounts of nutrients and oysters ability to provide ecosystem services (by filtering nutrients out of water) impacts decision-making, participants took part in one of three treatments, which were administered randomly. Recall, the central question of this study is to determine if and under what conditions consumers are willing to pay price premiums for the provision of eco-system services provided by oysters. For participants to have preferences for oysters that provide ecosystem services from waters that suffer from eutrophication as opposed to waters that are low or moderate in terms of nutrients, participants need to have information about the state of the water the oysters came from in terms of nutrient pollution – this information is given to everyone (N1-N4). However, it cannot be assumed that participants understand potential environmental impacts from eutrophication and, furthermore, oysters ability to improve water quality. The following three treatments provide different amounts of information concerning water quality and oysters contributions to their ecosystem, starting with a baseline treatment wherein no further information was provided to participants and two treatments that provided different levels of information.

Treatment 1 (T1): No Information was provided to participants (baseline treatment). In T1 participants based their purchase decision on the level of nutrients in the water the oyster was harvested from and the purchase price.

Treatment 2 (T2): Participants were provided with a scale (see Figure 1) used in NOAA's National Estuarine Eutrophication Assessment Update (Bricker et al. 2007), henceforth referred to as the "NOAA scale." The figure color-codes water quality depending on the nutrient-stress of the estuary. There are six different nutrient levels listed on the NOAA scale: (1) unknown, (2) low, (3) moderate low, (4) moderate, (5) moderate high, and (6) high. Oysters used in the experiment came from a location that was either unknown, low, moderate or high. Additionally, the NOAA scale included a one word assessment of the water quality based on the nutrients it was tested for, which provided the following information: "unknown" for an unknown nutrient level, "high" for a low nutrient level, "moderate" for a moderate nutrient level, and "bad" for a high nutrient level.

Treatment 3 (T3): Participants were provided with the NOAA scale (Figure 1) and additional information about the environmental concerns involving eutrophication and oysters ability to filter water. More precisely, the following additional information was provided to participants:

> *Nutrients, such as Nitrogen and Phosphorous, are naturally occurring elements that are essential for growth and reproduction in both plants and animals.*
>
> *Excess levels of nutrients, however, can cause overstimulation of growth of aquatic plants and algae, leading to algal blooms, oxygen depletion, clogged water intakes, fish kills, a general loss of key habitats, and affect the use of water for fishing, swimming, and boating.*
>
> *Oysters are filter feeders, consuming free-swimming algae and improve water quality.*
>
> *New research from the National Oceanic and Atmospheric Administration (NOAA) supports using shellfish aquaculture for nutrient removal.*
>
> *(This information comes from the Marine Biological Laboratory, the United States Geological Survey, the National Oceanic and Atmospheric Administration)*

Combining random price, oyster type (nutrient information) and treatments, results in 12 different decisions - four for each of the three treatments (table 1). Each participant took part in one of the three treatments (between-subject design) and made eight posted price decisions, two for each specific oyster type (based on the nutrients in the water the oyster was harvested from). Participants were randomly assigned to one of the three treatments. Furthermore, an algorithm randomly selected the order of the eight posted price questions to avoid potential order effects.

Implementation. Oysters were offered to participants to consume on site in two different ways: (1) raw - on the half shell and (2) breaded and deep-fried. Additionally, participants were able to take purchased oysters home, on ice in a provided bag. All experiments involved a professional oyster-shucking service, which included one or two professional shuckers and professional equipment to shuck and present the oysters. Moreover, having professional shuckers ensured that the experiments ensured food safety requirements and moved along quickly, so people did not have to wait for their oysters any longer than it would take a professional to prepare the oysters for consumption. Participants were able to inspect the oysters and professional shuckers, which were presented at a table ('oyster table'), however, none of the oysters were labeled and could therefore not be identified with the oyster type presented in the experiment. Participants made all purchasing decisions on mobile computer tables, which provided distance to the oyster table, such that participants' decisions would not be affected by conversations that took place at the oyster table. These experiments were carried out as field experiments at three different locations to ensure a broad and diverse sample. The first two experiments took place at two distinctly different brewpubs. The first one was a local crafts beer brewery were we sampled on a Friday night, their busiest night. The second location is locally known to serve alcoholic beverage at low prices and also attracts a large crowd on Fridays, especially at a "happy hour" during which data was collected. Neither of the two locations served food, ensuring that we did not compete with any in-house kitchens and food prices. Lastly, we collected data at a public community event, which attracts more than 8,000 spectators every year.

At the end of the experiments participants were asked to complete a short demographic survey, which, also included questions concerning their general and oyster-specific sea food consumption, whether participants were the primary sea food shopper in the household, general preferences for oysters such as color and shape, and for the brewpub locations, how many glasses of alcohol (wine, beer, liquor) participants had consumed.

3. Results

We collected data from 290 participants. As each participant made eight purchasing decision a total of 2,320 observations were used in the analysis. There are a total of 606 “Yes” decisions at an overall (across all three treatments) mean per oyster price of $1.23 and a standard deviation of $0.56. On the other hand, there are total of 1714 “No” decisions at an overall (across all three treatments) mean per oyster price of $1.63 with a standard deviation of $0.58. Therefore, on average and across all treatment, about one in four decisions resulted in “Yes.” The mean age was 34 years and the sample consisted of 45% male and 55% female participants. Some summary statistics pertaining to participants survey responses are provided in table 2. In order to gain insight into participants’ reactions to the three information treatments, we use a simple random effects logic model with the binary choice variable (Yes/No) as the dependent variable. Price and oyster types (nutrient information) are the explanatory variables, and we included gender as a dummy variable. In an earlier version we had also included age but decided to not include it as it was no significant and did not improve the overall fit of the model. The explanatory variables are reported in log likelihood units. Additionally, oyster type “unknown nutrients,” indicating the oyster type that had come from a location with unknown nutrients, as reported by NOAA (Bricker et al. 2007), is omitted. It follows, that the remaining oysters type coefficients ("low nutrients", "moderate nutrients" and "high nutrients") indicate the increase or decrease in the log-odds of the probability of participants deciding to purchase the specific oyster types. For example, the coefficient for "Moderate Nutrients" in treatment 1 (No Information) equals 1.2411 and is significant at the 1% level – indicating that participants in treatment 1 are significantly more likely to purchase oysters that have come from an estuary that contains moderate levels of nutrients, compared to oysters that come from a estuary that contains unknown levels of nutrients. The random effects model is summarized for person *i* in the following equation.

$$log\frac{P_{ij}}{1-P_{ij}} = \alpha + \beta_1 * D_{ij} + \beta_2 * L_{ij} + \beta_3 * M_{ij} + \beta_4 * H_{ij} + \beta_5 * G_{ij} + \mu_i + \varepsilon_{ij},$$

where $\mu_i \sim N(0, \sigma_\mu^2)$ and $\varepsilon_{ij} \sim N(0, \sigma^2)$ (1)

P is the probability of a Yes-decision, *D* is the oyster price, *L* are oysters from an estuary containing low levels of nutrients, *M* are oysters from an estuary containing moderate levels of nutrients, *H* are oysters from an estuary containing low levels of nutrients, *G* is the gender specific dummy variable, subscripts *i* and *j* pertain to the specific individual and decision.

The results of the random effects logit model are summarized in table 3. The first striking observation is that information concerning the level of nutrients in the water the oysters had come from appears to matter greatly to participant. In fact, all but one coefficient are significant at the 1% level, indicating that they are significantly more likely to purchase oysters that had come from an estuary that contains low, moderate and high levels of nutrients compared to the "unknown nutrient" case. The only coefficient that is not significant is "unknown nutrients" in treatment 1 (no information). Perhaps this may be attributed to terminology. Assuming that nutrients, in general, are perceived as something good and essential for growth and health in living organisms, one might think that a low level of nutrients in the estuary the oysters are grown in, may not provide critically important food for oysters and, therefore, have negative impacts on the quality of the oyster. This is no longer the case once participants receive information about the negative impacts of nutrients on water quality and ecosystems and oysters ability to filter nutrients from water. In fact, in treatment two and treatment three oysters from low nutrient waters are statistically significantly different from oysters from unknown nutrient waters, at the 1% level. Not surprisingly, we also find that price matters greatly to participants as reflected by the 1% significance level for all treatments, indicating that the lower the price the more likely participants are to purchase any of the oysters. The gender dummy reveals no significant difference between males and females in treatment 1 (no information). However, in both information treatments male participants are significantly more likely to purchase oysters compared to females at any price.

We further use the random effects logit coefficients to generate the price premiums participants are willing to pay for oysters in each of the three treatments (Figure 2). Price premiums are computed as quotient of *independent variable coefficient* over *price coefficient.* They are reported in US dollar amounts above the bars in figure 2 and specify the difference between the willingness-to-pay (WTP) for oysters from unknown nutrient waters (baseline) and the WTP for oysters from waters for low, moderate and high nutrient waters. Overall, we find that participants that received one of the two information treatments (NOAA scale or NOAA scale & additional info) are willing to pay higher price premiums for any of the oyster types. This appears to be in line with the previously stated result indicating that consumers are more willing to purchase oysters once they know the nutrient level of the water they oysters had come from – irrespective of the particular nutrient level. The most striking treatment effect appears to be for low nutrient oysters. When providing participants with information about nutrients participants price are willing to pay much larger price premiums for oysters from low nutrient waters. This difference is the largest between the no information treatment and the NOAA scale information treatment, where participants, on average, pay an additional $1.02 per oyster from low nutrient waters compared to an oyster from unknown nutrient waters. For oysters from moderate nutrient waters the difference in price premiums between the treatments is still substantial, with a price premium increase of $0.63 and $0.27 for the NOAA scale treatment and the NOAA scale & additional info treatment, respectively. Overall, the price premiums are smaller in the NOAA scale & additional information treatment compared to the treatment that only received the NOAA scale, perhaps suggesting that although participants respond favorably to information, in that they are willing to pay more for oysters in general than if they do not receive any information. However, too much information about nutrients and perhaps, especially, learning about oysters ability to filter water, might lead some participants to pay less for oysters in general – "too much of a good thing…" This effect maybe due to participants having to think about the oyster as a filter feeder and visualizing the process may result in disgust in some participants or participants might learn this fact about oysters in our experiments. In order to gain further insight into participants decision-making and the impacts of treatment and nutrient information, we use another random effects logit model including interaction effects between treatment and the nutrient level of the water the oyster had come from. Equation 2 summarizes the model for person i:

$$log \frac{P_{ij}}{1-P_{ij}} = \alpha + \beta_1 * D_{ij} + \beta_2 * L_{ij} + \beta_3 * M_{ij} + \beta_4 * H_{ij} + \beta_5 * T2_{ij} + \beta_6 * T3_{ij} + \beta_7 * (T2_{ij}L_{ij}) + \beta_8 * (T2_{ij}M_{ij}) + \beta_9 * (T2_{ij}H_{ij}) + \beta_{10} * (T3_{ij}L_{ij}) + \beta_{11} * (T3_{ij}M_{ij}) + \beta_{12} * (T3_{ij}H_{ij}) + \mu_i + \varepsilon_{ij}, \text{ where}$$

$$\mu_i \sim N(0, \sigma_\mu^2) \text{ and } \varepsilon_{ij} \sim N(0, \sigma^2) \qquad (2)$$

T2 and T3 stand for the treatment 1 (NOAA scale) and 2 (NOAA scale & additional info) and treatment 1 is the omitted baseline (no information), and as above, *P* is the probability of a Yes-decision, *D* is the oyster price, *L* are oysters from an estuary containing low levels of nutrients, *M* are oysters from an estuary containing moderate levels of nutrients, *H* are oysters from an estuary containing low levels of nutrients, *G* is the gender specific dummy variable, subscripts *i* and *j* pertain to the specific individual and decision. There are three primary results obtained from this model. First, we find that if oysters come from waters with unknown nutrient levels, providing participants with information does not have an effect – both coefficients for treatment 2 and 3 not significant (see table 4). This results appears intuitive, as participants do not know the level of nutrients in the water the oysters came from, providing them with information about nutrients and oysters ability to filter nutrient from water may not reveal sufficient information that might help them in the decision process.

Second, oysters that come from waters with moderate and high nutrients are significantly more likely to be selected in the no information treatment – both coefficients are significant at the 1% level. This result shows that participants may think of higher levels of nutrients in the water to provide additional benefits to the oyster and therefore improve oyster quality and/or taste. This result also speaks to the question of under which circumstances participants may have preferences for oysters that provide larger ecosystem services. Under the assumption that oysters provide larger ecosystem services the more impaired the estuarine system by eutrophication, then having participants prefer oysters from these waters, might require not telling them anything about the negative impacts of nutrients and oysters ability to filter water. In fact, sharing too much information with participants might stigmatize oysters that provide higher ecosystem services in the minds of the participants. This is an important result and might provide valuable information to other types of foods grown in ways that could potentially be beneficial from an environmental perspective but also be stigmatizing to consumers and is a potential question for further research in this area.

The third result dovetails with the above stigma reaction of participants. We find that when interacting the information in both of the information treatments (T2 and T3) with the different oysters types (L, M, H), participants are significantly more likely to select oyster from water with a low nutrient level. This result is statistically significant at the 1% level for the interactions between treatment 3 (NOAA scale and additional information) and oysters from low nutrient waters and marginally significant at the 10% level for treatment 2 (NOAA scale) and oysters from low nutrient waters. It appears that when participants are provided with enough information to choose between oysters that provide eco-system services versus oysters that come from waters that are cleaner in terms of nutrients, they prefer oysters from cleaner waters. This results is in line with previous findings that show that people are particularly susceptible to become stigmatized through oral exposure by a possible contaminant. In this case the contaminant may simply be the high levels of nutrient in the water the oysters are grown in. It may not matter that the nutrients do not increase the health risk associated with the consumption of oysters.

4. Summary

Eutrophication is a major environmental problem in many countries across the world with large economic impacts. In the United States, the National Oceanic and Atmospheric Administration (NOAA) supports the use of shellfish aquaculture for nutrient removal, such as oysters. Oysters are suspension feeders that filter phytoplankton from water thereby reducing organic matter, the primary driver of eutrophication. Oysters are part private good, providing a marketable consumption good, and part public good through the provision of eco-system services. These public good traits are typically not accounted for in the market, which leads to undervaluation of oysters in the market. “Green” markets have shown in the past to provide an outlet to privatize public goods by achieving price premiums – examples are shade-grown coffee and eco-tourism. However, oysters are different as they are grown in the water they clean and people might stigmatize these oysters if they associate the nutrient pollutions with polluting the oyster, while leaving the water cleansed. Our revealed preference dichotomous choice experiments test if and under what circumstances consumers are willing to pay price premiums for oysters that provide eco-system services. Willingness-to-pay estimate reveal that participants are sensitive to information about oysters ability to clean water and environmental impacts of eutrophication. We find that once we provide participants with information they are less likely to choose oysters from waters that suffer from eutrophication. However, not providing participants with information about oysters ability to filter water and environmental impacts of eutrophication, participants are more likely to select oysters from moderate and high nutrient waters. These results hold important policy implications. Especially in areas where oyster aquaculture is discussed as a potential eutrophication mitigation option. Investments in oyster aquaculture by public and private investors may also depend on the expected return on investment and knowledge about how to labeling these oysters to obtain the biggest return that would justify the investment into a partially private and public good may be viewed as very valuable.

Table 1. Experimental Design Overview

		Four decisions (within-subject design)			
		Oyster location (based on nutrients in water) - randomized order			
		Unknown Nutrients	Low Nutrients	Moderate Nutrients	High Nutrients
Three Treatments (between-subject design)	Treatment 1 (no information)	*(1) yes or no for random price*	*(2) yes or no for random price*	*(3) yes or no for random price*	*(4) yes or no for random price*
	Treatment 2 (NOAA scale)	*(1) yes or no for random price*	*(2) yes or no for random price*	*(3) yes or no for random price*	*(4) yes or no for random price*
	Treatment 3 (NOAA scale plus additional information)	*(1) yes or no for random price*	*(2) yes or no for random price*	*(3) yes or no for random price*	*(4) yes or no for random price*

Table 2. Selected Survey Responses

		Count	Percentage
Income Distribution	<$10,000	32	11.19%
	$10,000-$14,999	16	5.59%
	$15,000-$24,999	20	6.99%
	$25,000-$34,999	17	5.94%
	$35,000-$49,999	24	8.39%
	$50,000-$74,999	34	11.89%
	$75,000-$99,999	39	13.64%
	$100,000-$149,999	57	19.93%
	$150,000-$199,999	19	6.64%
	$200,000-$249,999	13	4.55%
	>$250,000	15	5.24%
		Count	**Percentage**
Preferred Consumption	Half Shell	99	34.62%
	Shooter	11	3.85%
	Fried	105	36.71%
	Grilled	49	17.13%
	Other	22	7.69%
		Count	**Percentage**
Political Affiliation	Conservative	77	27.80%
	Moderate	94	33.94%
	Liberal	106	38.27%
		Count	**Percentage**
Education	High School	38	13.15%
	Some College	94	32.53%
	Acociate's Degree	20	6.92%
	Bachelor's Degree	81	28.03%
	Graduate Degree	56	19.38%
		Count	**Percentage**
Annual Oyster Consumption	0	78	26.99%
	1-2	103	35.64%
	3-5	56	19.38%
	6-9	22	7.61%
	>9	30	10.38%
		1 (Not Important) - 9 (very important)	
General Oyster Preferences	Species	4.11	
	Shell Size	4.84	
	Meat Size	6.31	
	Shell Appearance	5.05	
	Saltiness	5.67	
	Smell	6.99	
	Shell Color	4.24	
	Meat Color	6.22	
	Harvest Location	5.56	

Table 3. Random Effects Logistic Regression by Treatment

	Treatment 1 (No Information)			Treatment 2 (NOAA Scale)			Treatment 3 (NOAA Scale and Additional Information)		
Yes - Decision	**N = 1040**			**N = 640**			**N = 624**		
	Coefficient	**St. Error**	**p-Value**	**Coefficient**	**St. Error**	**p-Value**	**Coefficient**	**St. Error**	**p-Value**
Price	-1.4766	0.1541	0.000	-1.0868	0.1652	0.000	-1.1450	0.1693	0.000
Low Nutrients	0.3184	0.2677	0.234	1.3512	0.2881	0.000	0.8040	0.3048	0.008
Moderate Nutrients	1.2411	0.2451	0.000	1.5958	0.2868	0.000	1.1561	0.2977	0.000
High Nutrients	1.2904	0.2455	0.000	1.0816	0.2936	0.000	1.0024	0.3002	0.001
Unknown Nutrients	(Baseline)			(Baseline)			(Baseline)		
Male	0.2637	0.1624	0.104	0.3726	0.1844	0.043	0.4610	0.1942	0.018
Constant	-0.0620	0.2786	0.824	-0.4249	0.3243	0.190	-0.4163	0.3287	0.205

Notes: Positive coefficient = participants are more likely to choose "Yes".

Table 4. Random Effects Logistic Regression Including Interaction Terms

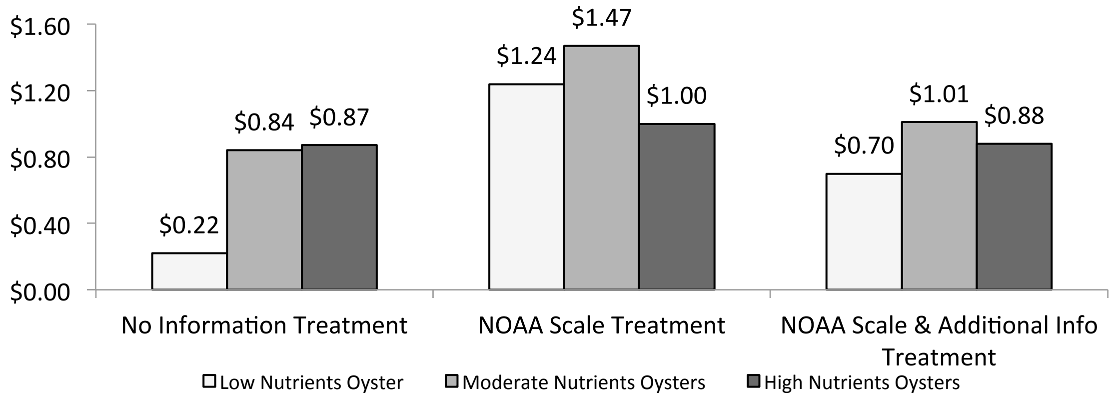
Yes - Decision	Coefficient	St. Error	p-Value
Price	-1.6548	0.1184	0.000
Low Nutrients (L)	0.2810	0.2869	0.327
Moderate Nutrients (M)	1.3714	0.2653	0.000
High Nutrients (H)	1.4139	0.2669	0.000
Unknown Nutrients		(Baseline)	
No Information Treatment		(Baseline)	
NOAA Scale Treatment (T2)	0.0518	0.3841	0.893
NOAA Scale & Additional Information Treatment (T3)	0.1692	0.3716	0.649
T2xL	0.7584	0.4454	0.089
T2xM	0.1009	0.4265	0.813
T2xH	-0.1614	0.4281	0.706
T3xL	1.3473	0.4306	0.002
T3xM	0.5461	0.4106	0.184
T3xH	-0.0887	0.4172	0.832
Constant	-0.0081	0.2729	0.976

Notes: Positive coefficient = participants are more likely to choose “Yes”. N=2,320.

Figure 1.

Nutrient Level	Unknown	Low	Mod. Low	Moderate	Mod. High	High
Water Quality based on Nutrients	Unknown	High	Good	Moderate	Poor	Bad

Figure 2. Price Premiums by Treatment



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Appendix A

Instructions

Please read these instructions carefully and do not communicate with any one while you are making your decisions.

- **We will give you $10 that you may keep and/or use to purchase oysters**. You may think of this money as a bank account from which you can withdrawal money.
- Depending on your decisions, you may receive a combination of cash and oysters. There is the possibility of you owing us money if the cost of your oysters is greater than $10.

Rules

(1) Decide how many oysters you would want to buy (3, 6, 9 or 12)
(2) Decide if you want to buy the oyster options at the listed price by selecting "Yes" or "No"
(3) Roll a die to determine which oyster option will be implemented (only one will be implemented)
(4) Fill out a short survey

Example 1: If you selected 'Yes' for an oyster bundle that cost $7 and this decision was implemented, you will receive the oysters and $3 cash ($10 - $7 = $3).

Example 2: If you selected 'No' for an oyster bundle and this decision was implemented, you will receive $10 and will not receive any oysters.

Example 3: If you selected 'Yes' for an oyster bundle that cost $15 and this decision was implemented, you will receive the oysters and owe $5 cash ($10 - $15 = -$5).

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