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Publication Date
2013-01-08

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CUDARE Working Papers

Year 2013	*Paper 1088R*
(Year 2012	*Paper 1088)*

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January 8, 2013

Abstract

Conservation organizations seeking to reduce over-fishing and promote better fishing practices have increasingly turned to market-based mechanisms such as environmental sustainability labels (eco-labels) in order to shift patterns of household consumption. This paper presents an analysis of consumer response to an advisory for sustainable seafood adopted by a regional supermarket in the United States. The advisory consisted of a label in which one of three traffic light colors was placed on each fresh seafood product to inform consumers about its relative environmental sustainability. Green meant "best" choice, yellow meant "proceed with caution," and red meant "worst choice". Using a unique product-level panel scanner data set of weekly sales and taking advantage of the random phase-in of the advisory by the retailer, we apply a difference-in-differences identification strategy to estimate the effect of the advisory on overall seafood sales as well as the heterogeneous impact of the advisory by label color and whether the seafood met additional health-related criteria. We find evidence that the advisory led to a statistically significant 15.3% decline in overall seafood sales, a statistically significant 34.9% decline in the sale of yellow labeled seafood, and a statistically significant 41.3% decline in the sale of yellow labeled seafood on a mercury safe list. We find no statistically significant difference in sales of green or red labeled seafood.

Keywords: Eco-labels, food certifications, traffic-light food labels, sustainable seafood.

1 Introduction

While a variety of states for different fish stocks and management practices have been improving [46, 13], there are substantial concern with respect to the state of many of the world's fish stocks[37, 50]. Population growth and higher per capita consumption are expected to drive global demand for seafood well above current levels [15, 14]. While aquaculture may be promising [46, 15, 7, 6], only a portion of this expected increase in demand is likely to be met by aquaculture [46, 15][1], meaning that over-fishing of wild seafood stocks could continue.

Confronted by this situation, conservation organizations seeking to reduce over-fishing and promote better fishing practices are increasingly turning to market-based mechanisms such as environmental sustainability labels ("eco-labels"[2]). Two widely recognized seafood eco-labels are the Dolphin Safe Tuna label and Marine Stewardship Council (MSC) certification[3]. The Food and Agriculture Organization of the United Nations estimates that there are now over 400 standards, certifications and labels related to wild fisheries and aquaculture [15]. A primary objective of most eco-labels is to provide a market-based incentive for more environmentally sustainable seafood production. Successful eco-labels may require that consumers pay a price premium in order to offset higher investments and operating expenses related to governance, technology and business process innovation [46]. Despite widespread and increasing use of eco-labels, there is sparse market-based evidence on whether eco-labels increase consumers' willingness to pay for product attributes linked to ecological sustainability or to alter household consumption patterns, and it remains an empirical and

[1]Concerns about potentially significant ecological impacts such as nutrient pollution, farmed fish escapes, disease spread, and the use of captured fish in feed may ultimately limit the potential of aquaculture to fully substitute for wild catches [3, 30].

[2]The FAO's definition of an eco-label is "a tag or label certifying that the fish product was produced in an environmentally friendly way. It provides information at the point of sale that links the product to the production process" [15].

[3]The Earth Island Institute's Dolphin Safe Tuna labeling program sought to stop the killing of dolphins inadvertently captured when schools of tuna were encircled in the nets used by tuna fisherman. The program created a government-defined environmental sustainability label that could be used by tuna producers to certify that their catch methods were dolphin safe. The Marine Stewardship Council's distinctive blue and white logo may be used by companies selling products from fisheries that a third party, independent organization has verified is environmentally sustainable throughout the entire production chain [53].

unresolved question whether these eco-labels do indeed affect consumer behavior.

This paper uses retail scanner data to investigate consumer purchase response to the FishWise Advisory, an eco-label adopted by a regional supermarket chain on the West Coast of the United States. The Advisory consisted of a label placed on every fresh seafood product to inform consumers about its relative environmental sustainability. The labels used a traffic light color schematic: green meant "best choice," yellow meant "proceed with caution," and red meant "worst choice". We take advantage of the random, phased introduction of the Advisory, and apply a differences-in-differences identification strategy to estimate the effect of the Advisory on sales overall, on sales by label color and on sales as an interaction with additional health-related information.

In the European Union and the United States, proposed legislation for standard front-of-pack nutritional labels has led to dynamic debate about the effectiveness of different label designs and calls for more research studying consumers' use of food labels in real-world settings [18][4]. We have identified one other market-based study specifically on the impact of traffic light labels. That study uses supermarket data from the UK, where the Food Standards Agency is recommending adoption of a traffic light label consisting of four color-coded lights representing the levels of sugars, fat, saturated fat and salt in a product [16]. The study found that such a system of four traffic light labels had no measurable effect on the healthfulness of consumer purchases [44].

A growing number of studies related to this paper have looked at consumers' stated preferences for seafood product attributes such as color [4], quality, and sustainability [23, 21], and how these these preferences vary by country [24], species, certifier and household attributes [51, 52]. Other studies have evaluated consumer preferences for product attributes in sectors such as wood products [1, 2, 33, 36, 35], firewood [48] and genetically modified foods [43] and how these preferences vary by location[28]. A related body of literature has evaluated

[4]On April 28, 2010, the United States Food and Drug Administration wrote that they were seeking public input on ways to "enhance the usefulness to consumers of point-of-purchase nutrition information." See: ://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm209953.html.

how consumers' awareness and knowledge change when presented with the information in an eco-label [38, 36, 10]. While these stated preference studies can yield important and relevant insights, most of the information is self-reported and offers limited insight into how consumers use labels in actual shopping situations [18]. There can be wide disparities between consumers' stated preferences and their actual purchases [34, 49]. The availability of information about a product does not necessarily mean consumers will incorporate it into their decisions and alter their behavior [25, 34, 22, 26, 20].

In the revealed preference literature, hedonic price models [8, 41, 42, 12, 27], demand system [47] and case study [39] approaches have been used to estimate relative values for seafood product attributes such as catch method, fishing gear choice, country of origin, product color (of salmon), and environmental sustainability. The two articles most relevant to our paper are Roheim et al. [41] applying an hedonic price function approach to scanner data on the sale of frozen, processed Alaskan Pollock in the London metropolitan market to estimate a statistically significant price premium for Marine Stewardship Council certification, and Teisl et al. [47] using consumer purchase data to confirm that the dolphin-safe tuna label increased the market share of canned tuna with the label. One has to look outside the seafood industry for additional empirically-based studies on the efficacy of food labels. Studies on restaurants hygiene [22], organic milk certification [25, 9], organic tomatoes and apples [54], and apparel [31] estimate significant relationships between attributes covered by these labels and price premiums or market share gains.

Additional evidence suggests there may be a discrepancy between the intended objectives of some eco-labels and the empirical results. After distributing more than a million wallet cards as part of its Seafood Watch program, the Monterey Bay Aquarium conducted a study that showed no overall change in market demand and no decrease in fishing pressure for targeted species[5]. In a review of 30 non-profit organizations with market-based sustainable seafood campaigns, the Bridgespan Group found no significant change in the buying practices or

[5]See Roheim for a thorough historical perspective on eco-labels in the seafood industry [40].

fisheries policies for ecologically sensitive fish populations [17]. Scientists now believe that the biomass of Marine Stewardship Council certified Alaskan Pollock, the largest single-species food fishery in the world and one that is often cited as an example of a market-based approach helping to drive an industry towards sustainability, may be declining as much as 50% below the year of 2008's levels [32]. However, while the stock estimates of Alaska Pollock have declined substantially, one cannot claim that is primarily due to overfishing, as variations in the ecosystem could be the most likely course.

The remainder of this paper is structured as follows. Section 2 presents our empirical strategy, including a discussion of the experimental setting, data and econometric specifications. Section 3 presents the results of the analysis. Section 4 discusses the implications of these results.

2 Empirical strategy

2.1 Experimental setting and data

2.1.1 Experimental setting

This study uses point of sales data from a local US supermarket retail chain (the "Retailer") operating ten stores in the San Francisco Bay Area, Northern California.[6] This chain is a typical supermarket chain, competing with other local and also other national retail chains. Consumers visiting this chain include some of the highest income households in the Bay area, so they do not represent all the income categories of the general population. In 2006, the Retailer partnered with a non-profit organization named FishWise to provide consumers with information about the environmental sustainability and healthiness of its fresh seafood products (the "Advisory"). Starting on May 17, 2006 the Retailer piloted the FishWise Advisory for twelve weeks at two randomly chosen stores and then fully implemented the

[6] We do not name the Retailer in order to protect its confidentiality.

Advisory at all stores on September 4.[7] The gradual phase-in of the program created a quasi-experimental setup with two treatment stores and eight control stores.

Table 1 provides descriptive statistics of store characteristics for the ten stores, based on a twelve week pre-treatment period beginning on February 19, 2006 and ending on May 17, 2006, and a twelve week treatment period beginning on June 10, 2006 and ending on September 3, 2006. These time frames exclude a four week period over which the Retailer implemented the program. During the pre-treatment period, the treatment stores had slightly higher weekly store sales ($404,707 versus $397,769), meat department sales ($30,653 versus $25,964), seafood revenue ($16,259 versus $11,898), seafood sales (732 versus 541 lbs) and store traffic (14,449 versus 11,126 shoppers) than the control stores. The difference in means are not statistically significant. The median annual household income of the zip codes in which the stores are located is $68,451, with a low of $38,613 and a high of $142,459. Shoppers at the control stores had a significantly higher average household income than treatment store shoppers.

It is not apparent from observable store characteristics and population demographics that the treatment stores are different from the control stores (Table 2). According to our findings and discussions with the Retailer, the Retailer selected treatment stores randomly as a result of budgetary constraints.[8]

The FishWise Advisory was developed by an independent non-profit organization using assessment criteria from the Monterey Bay Aquarium, and was licensed to the Retailer. Under the FishWise traffic light system, a color label was placed on the pin tag of each fresh seafood product. A label contains the traffic light color as well as the name of the seafood, the country of origin, whether the seafood was farmed or wild, the price per pound, and a small graphic depicting the catch method. As an example, a label would inform the consumer

[7] The Retailer began advertising the program in local newspapers on October 9, 2006.

[8] We run robustness check regressions on a subset of stores most similar to the treatment stores based on observable store characteristics, and the main results remain unchanged from the basic specification.

that the product is named Petrale Sole, has a FishWise environmental sustainability rating of "yellow," was caught in California using a bottom trawl, and is sold for $16.99 per pound (Figure 2). Because U.S. law requires country of origin labeling for fish and shellfish, labels in control stores contained only the product name, country of origin and sale price. The Retailer labeled all products sold at the fresh seafood counter. A consumer could therefore choose from a large number of seafood products, often had multiple label color options within a particular type of seafood (e.g. green, yellow and red salmon), and did not have an un-labeled seafood option. The Retailer updated the labels weekly on Tuesday nights after the stores had closed.

FishWise uses multiple criteria to assign a traffic light color to each seafood product: species, catch method, production method, and country of origin.[9] Green, "best choice," means that these species are abundant and/or well managed and are caught or farmed in environmentally friendly ways. Yellow, "good alternative," means that these species come from fisheries or farms with good quantities, but that there are still some environmental concerns. Red, "unsustainable," means that these species are caught or farmed in ways that cause substantial harm to the environment. During the time frame of this study, FishWise updated the traffic light color assignment for each product on a quarterly basis.[10]

The Retailer did not include health information on the pin tag label. Instead, health information was presented on a poster located immediately adjacent to the fresh seafood counter. This poster contained a list of the seafood with low levels of mercury and poly-chlorinated biphenyls (PCBs), two chemicals known to have harmful effects on humans. To be included on this list, a product must be both rated as either green or yellow in terms of environmental sustainability and also be low in mercury and PCB content (Figure 3). The list does

[9] A seafood does not need to rank highly on all criteria to receive a green rating. A green rating, for example, could be given to a fishery with low wild stocks, but which has high ratings on all the other criteria.

[10] We have extensively investigated how we could obtain information about whether a consumer actually reads and uses the FishWise information. Unfortunately, we found that this information or anything related to it is not available. The Retailer did not conduct exit interviews or surveys as part of the implementation of the labeling program.

not contain any red-labeled products. To be clear, inclusion on the list is good; excluded products are assumed to have high levels of mercury and PCBs. The Retailer also displayed a second poster near the seafood counter containing an interpretive guide to the label colors and catch methods.

In this analysis, we assume that the Retailer's consumers obtain their information about the environmental sustainability and healthfulness of their seafood products only from the FishWise Advisory. However, starting in 1999, the Monterey Bay Aquarium's Seafood Watch program began distributing pocket guides and doing outreach to inform consumers about seafood sustainability. We do not have information about which consumers shopping at the Retailer also had access to these wallet cards. We discuss the potential impact that the availability of these cards, as well as other sources of information, could have on the estimates in Section 4.

2.1.2 Data

The analysis for this study uses several unique panel data sets. From the Retailer, we obtained weekly product- and store-level scanner data for 2006. The scanner data set contained weekly sales data by fresh seafood product[11] sold at the fesh seafood counter: date, store, seafood type (e.g. salmon), product name (e.g., King Salmon), unique product number, unit sales, dollar sales, units, unit returns, dollar returns, full retail price per unit, discounted price per unit, cost per unit, gross margin, and country of origin (N=7841). The Retailer provided scanned copies of weekly, product- and store-level records containing the dates and details of special advertisements and promotions for each product. After converting this information to database format, we merged it with the scanner data set. Extracting the data from quarterly reports provided by FishWise, we then reconstructed a weekly record

[11]This study only evaluates fresh seafood sales. Fresh seafood is only sold at the counter and is not sold elsewhere in the store as, for example, pre-packaged products in the meat section of the store.

of the assignment of label colors by product as well as each of the individual variables that contributed to the color label: country of origin catch method, and production method. We verified that these color assignments matched a partial record of color assignments maintained by the Retailer, which had discarded earlier records of the color assignments. Finally, using quarterly reports provided by FishWise, we reconstructed a weekly record of seafood products that were contained on a list of fisheries that had low levels of mercury and PCBs.

Average weekly seafood sales represent approximately 2-3% of total store sales (Table 1). Salmon, shrimp and halibut are the top three types of seafood by revenue, with salmon representing approximately three times more revenue per store than shrimp (Figure 4).

There was no statistically significant difference in the number of seafood product choices for an average week and store in the pre-treatment and treatment periods. In an average week and treatment store during the pre-treatment period, customers could choose between 34 different fresh seafood products (Table 2). If these products had been labeled using the FishWise Advisory, 13 of the products would have been green, 9 of them would have been yellow and 11 of them would have been red. In an average week and control store during the pre-treatment period, customers could choose between 32 different fresh seafood products. If these products had been labeled using the FishWise Advisory, 12 of them would have been green, 10 of them would have been yellow and 11 of them would have been red. There is some evidence that the number of red products decreased in both treatment and control stores during the treatment period (11 to 9 products in the treatment stores and 11 to 10 products in the control stores). Otherwise, the number of product choices was similar between pre-treatment and treatment periods.

There was also no statistically significant difference in product characteristics for an average week and store in the pre-treatment and treatment periods. In an average week and treatment store during the pre-treatment period, 56.7% of the products would have been listed on the low-mercury list if the FishWise Advisory had been in place, 30.4% of products were on sale, 52.2% of products were wild (versus farmed) and 36.6% of products were caught in the United States. These numbers are very similar to those for the control stores, and these figures do not vary much between pre-treatment and treatment periods.

These average weekly figures disguise some variation between stores (Figure 5). While all stores sold the three label colors of seafood, average weekly sales for seafood during the pre-treatment period ranged from a low $3,176 to a high of $11,931. Moreover, seafood sales and the number of product choices appear to be positively correlated. Of note, stores 2 and 4 appear to have the lowest number of products and sales.

The Retailer stated that it did not adjust its pricing or promotional activity in response to the labels during the weeks immediately before and after implementation of the FishWise Advisory. Table 3 evaluates this statement by comparing pricing for treatment and control stores during the pre-treatment and treatment period. During the pre-treatment period, the average (sales weighted) price for all seafood was $13.41 in the treatment stores versus $13.09 in the control stores. During the pre-treatment period in the treatment stores, the average price for green, yellow and red seafood was $13.22, $13.60 and $12.91 versus $12.10, $13.44 and $14.22 in the control stores. In addition to the overall figures and figures for green, yellow and red seafood, Table 3 provides average prices for the top ten products by revenue in both the control and treatment stores. Using the p-value of a simple t-test comparison of means, it appears that any price changes were consistent across both the treatment and control stores. That is, we do not find evidence of differential price manipulation between treatment and control stores.

2.2 Econometric specifications

Our empirical econometric model is a reduced form specification where we project the quantity purchased of seafood items on seafood product characteristics. We use this reduced form approach in a product- and store-specific fixed effects model[12] to estimate the average treatment effect of the Advisory as well as heterogeneous treatments effects depending on

[12]Note that this FE estimator is the panel data version of the differences-in-differences estimator for two pooled cross sections.

label colors and inclusion on a mercury safe list. This reduced form specification can be seen as an incomplete demand system that has a structural model behind it, as for example specified in Gudmundsson and Wessells [19]. In Gudmundsson and Wessels, consumers choose between goods to maximize utility subject to a budget constraint. Consumer utility is additively separable in product attributes and goods are substitutes along attributes such as price and quality. In this model, eco-labels are an additional attribute that differentiates labeled from unlabeled products.[13]

In our choice of statistical models, we are particularly concerned about the possibility of unobserved product heterogeneity that may be correlated with observed regressors. Examples include possible correlation between unobserved product attributes such as seafood freshness and price, correlation between seafood appearance (e.g. the color of salmon) and price, and correlation between the color of the FishWise Advisory label and a product's counter placement (e.g. green labeled seafood products tend to be closest to the shopper). Unobserved heterogeneity correlated with explanatory variables would lead to omitted variables bias and inconsistent parameter estimates using the ordinary least squares estimator.

Our preferred econometric model is a product-specific fixed effects model, which allows each product to have a different intercept term that captures unobserved heterogeneity that is potentially correlated with observed, explanatory variables. Relative to the random effects estimator, the fixed effects estimator is less efficient; however, we are unwilling to make the necessary assumption for the random effects model that the composite error term is uncorrelated with the explanatory variables. The standard form of the Hausman test led us to strongly reject the null hypothesis that the random effects estimator provides consistent estimates (overall test statistic,χ^2, has $p = 0.000$).

[13] In the partial equilibrium reduced form analysis in this present paper, the label will shift the demand curve for labeled products, assuming consumers associate a positive value to an eco-label. A general equilibrium approach would then consider what supply side changes would occur given demand changes. This general equilibrium approach is the topic of a future project using a structural model of demand and supply in the spirit of Gudmundsson and Wessells [19]. In the structural model, we are not only able to estimate the effect of the labels, but we can also use the structural model to simulate the effect of several alternative policies such as changes in labels and prices resulting from regulations mandating better fishing practices.

In all regressions, we use standard errors clustered at the seafood type level, as conventional standard errors have been shown to perform poorly in the context of difference-in-difference estimators in the presence of arbitrary serial correlation within each cross-sectional unit [11]. The presence of serial correlation in errors for each product would mean that standard errors are biased downwards. In order to ensure valid statistical inference, we control for both serial correlated and heteroskedastic errors using clustered standard errors at the store level (allowing for residuals that are correlated for the observations in a store). In our robustness checks, we also use a pooled OLS estimator with clustered standard errors to obtain parameter estimates. The following paragraphs explain the product-specific fixed effects models we use, and in particular we note that we define the panel variable as a store-product combination.

2.2.1 Average treatment effect

We start by using a product-store-specific fixed effects model with errors clustered at the store level in order to estimate the overall treatment effect of the FishWise Advisory (Table 4). Note that this FE estimator is the panel data version of the differences-in-differences (DID) estimator for two pooled cross sections. This sub-section describes the five specifications we use to estimate this overall effect. In all specifications, we regress the natural log of the quantity of seafood sold on an indicator variable for whether the product was in a treated store during the treatment period, a full set of store-product fixed effects, a full set of week dummies, and additional covariates depending on the specification. In the basic model, specification one of Table 5:

$$ln(Q_{ist}) = \beta_0 + \beta_1 t_{it} + \beta_2 \left(T_{is} * t_{it}\right) + c_{is} + v_t + \epsilon_{ist} \quad (1)$$

Q_{ist} are the ounces of seafood i sold in store s in week t. The model has $i = \{1, ..., I\}$ differentiated products, $s = \{1, ..., S\}$ stores and $t = \{1, ..., T\}$ time periods. The panel variable is a store-product, thus c_{is} is the store-product fixed effect. v_t is time-specific fixed effect. $t_{it}$is an indicator variable that is equal to one during the treatment period and zero during the pre-treatment period. T_{is} is an indicator variable that is equal to one for treatment stores and zero for control stores. The interaction of t_t and T_s is equal to one if product i is sold in the treatment store s during the treatment period. Thus, β_2 is the parameter of interest, representing the average effect of the FishWise Advisory across all three label colors. This parameter may be interpreted as the average percentage change in sales resulting from the implementation of the FishWise Advisory.

The previous specification will capture any constant, unobserved product characteristics that may be correlated with the observed regressors. In specification two, we include an interaction term of week and seafood type (e.g. salmon, halibut) to account for any time variant (seasonal) characteristics of different types of seafood.

$$ln(Q_{ist}) = \beta_0 + \beta_1 t_{it} + \beta_2 \left(T_{is} * t_{it}\right) + \beta_3 (f_i * w_t) + c_{is} + v_t + \epsilon_{ist} \quad (2)$$

Specifications three to five contain a combination of additional covariates.

$$ln(Q_{ist}) = \beta_0 + \beta_1 t_{it} + \beta_2 \left(T_{is} * t_{it}\right) + \beta_3 (f_i * w_t) + x_{ist}^{'} \theta + c_{is} + v_t + \epsilon_{ist} \quad (3)$$

x_{ist} is a row vector containing some combination of the following variables, depending on the specification: natural log of price ($ln(price)$), an indicator variables for the presence of a product promotion at the store level ($promo_{ist}$), the percentage discount off the full retail price ($discount_{ist}$), the fraction of total store sales and fraction of total meat department sales generated by the fresh seafood counter ($p - totalsales_{st}$ and $p - meatsales_{st}$), the fraction of seafood products in a store on the low-mercury list ($p - mercury_{st}$), and the fraction of green, yellow and red products ($p - green$, $p - yellow$, $p - red$).

Specification three includes the price-related regressors to control for store-level price variation. The Retailer did not systematically manipulate pricing in the control and treatment stores during the pre-treatment or treatment time frames. However, the Retailer's pricing policy did allow store-level discounting to move expiring product and a very limited number of store-level promotions. Our estimates for price are actual prices, obtained by dividing total sales by total pounds of seafood sold for that week. Our estimate for each product's discount is the percentage difference between actual price and list price. We obtained information on the location and timing of promotions from the Retailer's database.

Specification four includes the covariates for the fraction of total store sales and fraction of total meat department sales generated by the fresh seafood counter. Although store-level fixed effects will account for any unobserved differences across the stores, these covariates will capture the impact of any weekly variation in sales. For example, weeks with a relatively larger proportion of sales might attract a subset of the population that is less educated about seafood sustainability than the customer population in lower revenue weeks.

Specification five includes the covariates for the fraction of seafood products in a store on the low-mercury list and the fraction of green, yellow and red products. Figure 5 shows that all ten stores sold a mix of green, yellow and red seafood in each week; however, this figure also suggests a correlation between the average number of products sold and average weekly sales. The Retailer stated that the same products were available in all stores. Because we cannot verify the accuracy of this statement, these covariates to address the possibility that any variation in the availability of each color seafood as well as seafood on the mercury safe list might affect sales.

2.2.2 Treatment effect by label color

Next, we estimate the treatment effect of the FishWise Advisory by the color of the pin tag label (Table 5). Specifications six to ten add a set of indicator variables for each of the label colors to the product-specific fixed effects model previously described.

$$ln(Q_{ist}) = \alpha + \beta_1 (color_{ist} * t_{it}) + \beta_2 (color_{ist} * T_{is} * t_{it}) +$$

$$+\beta_3(f_i * w_t) + x'_{ist}\theta + c_{is} + v_t + \epsilon_{ist} \quad (4)$$

$color_{ist}$ is a set of indicator variables for each of the label colors. β_2 is the variable of interest. x_{ist} contains the same variables as those described in the estimation of the average treatment effect.

If the labels provide primarily environmental sustainability information to consumers, we would expect to see a heterogeneous effect from each of the different label colors sales. We would expect to see a similar change irrespective of the label color if the labels act only to publicize seafood. In this latter case, note that the sign of the treatment effect could be either positive or negative. The FishWise Advisory could cause a negative publicity effect if the labels and information dissuade consumers from purchasing fresh seafood.

2.2.3 Treatment effect by label color and health information

Finally, we estimate the treatment effect of the FishWise Advisory by the color of the pin tag label and whether the product was on the list of low-mercury seafood (Table 6). Specifications eleven and twelve apply the final specification developed to evaluate the treatment effect by label color to a) a data set with only those products on the low-mercury list, and b) a data set with only those products not on the low-mercury list.

3 Empirical results

We start with a graphical analysis in which we plot weekly sales by color label for store five and store one, two stores that are similar based on observable characteristics (Figure 6). To the left of the first vertical line, this figure shows 12 weeks (between February 19 - May 16, 2006) of average weekly sales in the treatment and control stores before the FishWise pilot. To the right of the second line, this figure shows 12 weeks (between June 12 - September 3) of average weekly sales in the treatment and control stores when the chain was piloting FishWise. The supermarket phased in the FishWise program over a 4-week period at the treatment stores, represented by the period between the two vertical lines on each graph. This figure has two important features. One, the pre-treatment trends in the control and treatment groups appear to be similar. That is, the difference between treatment and control groups is relatively constant over time, suggesting that a differences-in-differences estimator is indeed appropriate for this analysis. Two, the figure suggests that sales of yellow labeled seafood in treated stores declined relative to sales of yellow labeled seafood in the control stores during the treatment period. In comparison, sales of green and red labeled seafood appear to maintain the same difference between treatment and control store during the pre-treatment and treatment periods.

3.1 Average treatment effect on total sales

We begin the regression analysis by estimating the average treatment effect of the FishWise Advisory on total seafood sales. Recall that our hypothesis is for the Advisory to have no overall effect on seafood sales. Table 4 presents the results of using the fixed effects estimator described previously to an unbalanced panel data set in which the panel variable is store-product and the panel includes twenty-four weeks of weekly data (N=7841). The dependent variable for all regressions is the natural log of the number of pounds of seafood i sold in store s in week t. Thus, the parameter estimates for the treatment effect are interpreted as the percentage change in sales resulting from the FishWise labeling treatment. Note that this table does not report estimates for the treatment store dummy because this is time invariant and consequently drops out of the fixed effects regression.

The regression results presented in Table 4 provide some, albeit weak, evidence that the FishWise Advisory had a significant and negative effect on overall seafood sales. The estimated treatment effects across the five specifications vary between -11.9 to -15.3%. Only this last point estimate, in which we use all relevant regressors, is statistically significant ($p<0.10$). Specification one contains treatment period dummies, treatment effect dummies (the interaction of the treatment store and and treatment period dummies), store-product and week fixed effects. Specification one will capture any constant, unobserved product characteristics. The inclusion of an interaction term for week and seafood type (specification two) to control for seasonality in the availability and characteristics of different types of seafood (e.g. wild, locally caught salmon) has little impact on the point estimates or standard error of the treatment effect. It does, however, substantially increase the variance explained by the model (0.0013 to 0.1130). The addition of price-related covariates (specification three), the fraction of store sales driven by fresh seafood sales (specification four) and the fraction of products labeled as green, yellow and red (specification five) all cause very slight changes in the treatment effect point estimates and standard errors.

The parameter estimates for the additional regressors offer additional insight into the drivers of the Retailer's seafood sales. Pricing-related parameter estimates are consistent with our expectations. Although the estimate is not statistically significant, price is inversely correlated to sales and has a relatively small impact, which we expect given the Retailer's stated approach of not manipulating price during the pre-treatment or treatment periods. Promotions have a significant positive effect on sales ($p<0.01$). Later in the analysis, we return to the surprising result that inclusion on the mercury safe list has a significant negative effect. The parameter estimates for the treatment period dummy are not statistically different from zero, indicating that overall sales were similar during the pre-treatment and treatment periods.

3.2 Treatment effect by label color and health information

We then extend the regression analysis to evaluate whether the FishWise Advisory had a heterogeneous effect by the color label (Table 5). Our hypothesis is for the Advisory to have heterogeneous effects based on the color of the pin tag label: green-labeled seafood sales will increase, red-labeled seafood sales will decrease, and yellow-labeled seafood sales will rise less than green-labeled seafood (if yellow-labeled seafood sales increase), or conversely, yellow-labeled seafood sales will drop less than red-labeled seafood sales (if yellow-labeled seafood sales decrease). Thus as described previously, the parameter values of interest in these five specifications are those on the interaction of the label color with the treatment effect (equation 4). Otherwise, the additional regressors in each equation are the same as those we used to evaluate the average treatment effect. These parameter estimates for these regressions provide strong evidence that the treatment effect does vary by color label, which is consistent with the labels providing primarily environmental sustainability information to consumers. Across the five specifications, we estimate a statistically significant decline in sales of yellow labeled seafood ranging from -31.1% to -34.9% ($p<0.01$). In real terms, the 30% significant drop in yellow labeled seafood corresponds to a drop from about an average across stores of 20% of consumption to an average across stores of 14% of consumption.

For green labeled and red labeled seafood, we fail to reject the null hypothesis, i.e., we find no statistically significant difference in sales of green or red labeled seafood. While this is a surprising result, estimates of no willingness to pay for "better" alternatives have been also found in other settings and could be correlated with attributes of consumers [48] or of the store itself [28]. For instance, if green labeled products are on average more expensive, consumers could be too poor to choose the green alternative (thus not leading to an increase according to the null hypothesis), or be too poor to switch away form the red alternative (thus not inducing a drop as the null hypothesis stated). Without having an individual level panel dataset and consumer characteristics we cannot formally investigate this possibility as Van Kempen does [48]. As McFadden finds, the store choice itself may affect the way people make choices among alternative featuring certain "green" or "fair" attributes [28]. As we do not have data for different retail formats we can also not formally investigate this hypothesis.

As with the average treatment effect regressions, inclusion of interaction terms for week and seafood type significantly increases the variance explained by the model without substantially altering the point estimates (specification seven) . We interpret this result to mean that cyclicality of unobserved characteristics related to each seafood type is not correlated with other covariates related to the treatment effect. The parameter estimates for price are positive, but not statistically different from zero. The additional control variables for the fraction of store sales driven by the seafood department (specification nine) and the fraction of products on the low-mercury list with either a red, yellow or green label (specification ten) have a negligible effect on the point estimates and standard errors for the treatment effect. We interpret specification nine as evidence that weekly variation in seafood sales relative to total store sales was not correlated with substantially different customer populations who might respond differentially to the FishWise Advisory. We interpret specification ten as evidence that, conditional on the observed availability of seafood products of each color type (all stores had all three colors in all weeks), the fraction of seafood of each color type also did not have a significant impact on the effect of the FishWise Advisory. Unlike the average treatment effect regressions, the parameter estimates for the interaction of label color by treatment period suggest that sales of yellow and red labeled seafood declined across all stores between the pre-treatment and treatment period.

In the final part of the analysis, we return to the finding that the parameter estimate for the low-mercury list dummy variable was significantly negative. Given that consumers face conflicting reports on the risks and benefits of fish intake [29][14], consumers may confront the adverse and beneficial health effects of fish consumption. In particular, if they consider a fish as a bundle of attributes, consumers may focus on the potential harm from mercury, dioxins, and polychlorinated biphenyls (PCBs) present in some fish species, and the potential benefits from other fish attributes such as Omega 3. In our study, the low mercury label highlights one product attribute only, and consumers may be aware of other product attributes positively or negatively correlated with the displayed attribute, and it is based on this information that they make their choices. If a consumer associates low mercury with a low amount some other good fish attribute, then the negative estimate is reasonable. Given the results of Mozaffarian and Rimm, our results would be consistent with a healthy consumer moving

[14] See **(author?)** [29] for a review and discussion of the scientific evidence.

away from low mercury and preferring seafood that is high in both Omega 3 and mercury. Given that such "fatty" fish tend to have both the highest mercury level and the highest Omega 3 levels, choosing a seafood product high in both attributes would reveal that this consumer values Omega 3 more than health risks associated with mercury.

While our results show that on average consumers decrease consumption for species in the low mercury list, but does it matter whether low mercury is associated with a certain label color? We answer this question by evaluating whether the FishWise Advisory had a heterogeneous impact depending on whether the seafood was included on the list of low-mercury fish (Table 6). Our hypothesis is that the effect of the mercury content information depends on the label color: seafood products that are green and have low-mercury content will have a greater increase in sales than seafood products that are only green. For seafood on the low-mercury list, we estimate a statistically significant decline of 41.3% ($p<0.05$) in sales of yellow labeled seafood in treatment stores relative to the same unlabeled products in control stores. We fail to reject the null hypothesis of no effect for green and red labeled seafood. For seafood not on the low-mercury list, we find no statistically significant change in any of the label colors. This result, which is consistent with the significant negative parameter estimates for the low-mercury list, suggests that it is the effect of the FishWise Advisory on sales of yellow labeled seafood that are also on the low-mercury list that is driving the overall effect on yellow labeled seafood sales.

3.3 Robustness checks and placebos

We perform a set of robustness checks and placebos using specification ten, the preferred fixed effects estimator for heterogeneous effects by color label. In our interviews, the Retailer stated that the treatment stores were randomly chosen. The internal validity of this analysis hinges, however, on whether the control and treatment stores would have had similar sales trends without the implementation of the label, or conversely, with the implementation of the label. We are likely to obtain biased point estimates if the Retailer selected the treatment stores because consumers in these stores were expected to behave differently than consumers in the control stores. For example, if control store consumers were not really fish consumers, we would expect an upward bias in our estimates. Our results would also be likely to be biased if customers at treatment and control stores had substantially different awareness and information about seafood sustainability prior to the implementation of the program. One way in which the latter might happen is if customers at each store were influenced by different media outlets. For example, editorials in the San Francisco Chronicle might have preferentially altered consumers' behavior in the city of San Francisco relative to customers in the East Bay. Unfortunately, due to the fact that the stores implemented this program prior to our obtaining the data, we do not have access to exit interviews or any other information about store customers, their prior knowledge, or the extent to which they read and utilize information posted in stores. Thus, to address the two concerns just described, we ran specification ten for two sub-sets of stores: only stores located in the East Bay and only for the eight stores whose observable characteristics were most similar (Table 7, columns two and three).

The point estimates for the treatment effect are robust to several alternative time frames and sub-sets of the data (Table 7), the specifications for which are discussed in the previous section. In comparison to the preferred specification for evaluating the heterogeneous effect of the labels (column one), limiting the set of control stores to those in the East Bay has minimal effect on the treatment effect point estimates and standard errors (column two). We interpret this result as evidence that store populations in the East Bay and San Francisco areas were not significantly different in some unobserved way. Similarly, excluding the two stores (store two and store four) most different from the treatment stores in terms of their observable characteristic had little effect on the parameter estimates and standard errors for the treatment effect (column three). We interpret this result as evidence that, where treatment stores had significantly higher sales, this was not indicative of substantially different behavior by those store customers. Using a shorter time frame for the panel data set (columns four and five) also does not significantly affect the point estimates; however, limiting the panel data set to only four weeks of pre-treatment and treatment period data does cause the standard errors for the yellow labeled seafood treatment effect to increase considerably. We interpret the results of these two panel durations as evidence that we are not failing to capture important, time varying elements of the store populations.

Another potential issue with our analysis is that there may be time-varying elements of the customer populations that impact seafood sales differently between treatment and control stores. The included store-product fixed effects may not capture all relevant information regarding these time-varying elements of the population. In turn, the week fixed effects will only capture those time varying elements that have a similar effect for all stores. In order to evaluate whether these time-varying elements bias our results, we run specification ten for eight and four weeks of pre-treatment and treatment data.

As additional robustness checks, we ran specification ten on three types of placebos: time, label color and store. As the time placebo, we ran specification ten on randomly selected twenty-eight week intervals prior to the pilot. As the label color placebo, we ran specification ten after randomly re-assigning the product label colors. As the store placebo, we dropped the two treatment stores from the data set and then re-ran specification ten after randomly assigning two stores to be the treatment stores. As a final robustness check, although we are concerned about unobservable product characteristics that are correlated with the explanatory variables, we ran the ordinary least squares on the pooled cross-sectional data in order to estimate the general differences-in-differences estimate (Table 8). The placebo regressions for treatment store assignment, the time frame of analysis, and label color assignment all led to parameter estimates for the treatment effects that were not statistically different from zero.

As a final robustness check, we investigate whether the Advisory had an effect on wine sales, a category where, a priori, we would not expect an effect. We chose not to analyze other categories such as meats that could either be complements or substitutes for seafood and thus would in fact be impacted indirectly by the treatment. We ran ordinatry least squares on the pooled cross-sectional data in order to estimate the general diferences-in-differences estimator. We report the point estimates for the average treatment effect in the wine category in Table 9. We find no significant effect of the Advisory on that wine sales.

The results of these robustness checks further substantiate our conclusion that the observed effect on fresh seafood sales is the result of the FishWise Advisory.

4 Conclusion

Unlike Sacks et al.'s study utilizing supermarket data from the UK in which they found that a system of traffic light labels for four health-related product attributes no measurable effect on healthfulness of consumer purchases, our results offer evidence that the FishWise Advisory did influence consumer behavior [44]. Our divergent results could be due to the fact that we analyzed a different food category, information, retailer and region. Notably, both the Retailer and the region for this study are considered to be very environmentally aware. Other studies in the literature have shown that preferences can vary considerably by country [24], species, certifier and household attributes [51, 52] consistent with our results suggesting that there are different groups of consumers with different preferences for sustainable seafood.

Notably, the effect of the Advisory on sales was not consistent with our original set of hypotheses relating to heterogenous impacts based on the label color: an increase in green labeled seafood sales, a decrease in red labeled seafood sales, and a proportionally smaller change relative to green and red labeled seafood in yellow labeled seafood sales. Instead, we find evidence that the Advisory led to a statistically significant 15.3% decline in overall seafood sales driven primarily by a statistically significant 41.3% decline in the sale of yellow labeled seafood on a mercury safe list. We fail to reject the null hypothesis of no effect for green and red labeled seafood, i.e. the Advisory did not affect sales of green or red labeled seafood.

The available data and the partial equilibrium, reduced form nature of this analysis do not allow us to make causal interpretations of these results. Several potential explanations exist for these results, and research into consumers' prior knowledge and assumptions as well as substition patterns would be needed in order to conduct the structural analysis necessary to better understand the effect of the FishWise Advisory. With respect to the effect of the yellow labels, one possible explanation is that consumers who thought they were purchasing a good seafood based on inclusion on the mercury safe list received seemingly conflicting information once they were informed by the yellow label to "proceed with caution." The drop in sales of yellow labeled seafood, without an increase in sales of green labeled seafood, may have occurred because appropriate green labeled substitutes for the yellow labeled seafood may not have been available, or even if available, consumers may have been unwilling to pay higher prices for suitable green labeled substitutes. Our analysis (Figure 5) indicates that all stores sold some of each color label seafood; however, this reduced form analysis does not allow us to estimate consumers' cross price elasticities of demand between types of fish and color labels.

Possible explanations for the lack of an impact on the sale of green and red labeled seafood include consumers' prior information and assumptions, and like yellow labeled sales, the availability and pricing of desireable substitutes. The study location means that a large group of consumers would have had access to information about seafood sustainability through the Seafood Watch's wallet cards, which have been widely available in California for more than ten years. In the study region, many individuals concerned about environmental sustainability might have already shifted their consumption patterns to seafood that would have been labeled either green or red under the FishWise Advisory. Thus, for these informed consumers, the FishWise Advisory would have been consistent with their prior beliefs, but would not have served as new information. A consumer purchasing red labeled seafood would already have been aware of the environmental impacts associated with this purchase or would have also ignored this information in other guides, and thus could not be expected to change his or her purchasing patterns. Similarly, consumers disposed to purchase environmentally sustainable seafood would have already been doing so.

The study location may have influenced the results in other ways as well. On the one hand, consumers' prior access to sustainability information would mean that this study likely underestimates the impact of the labeling program. On the other hand, consumers' higher-than-average education levels and environmental awareness in the study region mean that we are likely to overestimate the impact of the program at a national scale. On average, these customers at the Retailer in this study have more years of education, higher income levels, and a higher probability of belonging to either the Democratic or Green parties than the national average. Shimshack et al. [45] identified education as a key factor determining the responsiveness of consumers to a United States Food and Drug Administration advisory about risks of methyl-mercury poisoning from store-bought fish. In that study, Shimshack et al. viewed education as a proxy for a person's ability to obtain and assimilate knowledge; they subsequently evaluated the difference in impact between readers and non-readers. In Shimshack et al's [45] study, the most educated consumers significantly reduced their fish consumption. However, the least educated group of consumers were not responsive to the advisory [45].

Many of the questions raised in the prior discussion could be addressed with supplemental data and different analytical techniques. We believe two general areas of effort would be warranted. One, it would be valuable to conduct pre- and post-surveys as well as to interview consumers in order to better understand their assumptions and knowledge. Two, having panel data available at the level of products and consumers would allow for structural modeling to better identify patterns of substition.

Considerably more research is needed to address these methodological limitations and to establish the robustness of our results in other settings and experimental conditions. This is one study with a set of results from one limited geographical area. Johnston et al., for example, show that there are systematic differences between the US and Norwegian consumers when it comes to eco-labels for fish [24]. Subject to this caveat, we draw a handful of important conclusions from our analysis of the FishWise Advisory. From an environmental perspective, the optimal outcome of the FishWise Advisory would be for green labeled seafood sales to increase and yellow labeled and red labeled seafood sales to decrease. Although consumption of green and red labeled seafood did not change, the decrease in yellow labeled seafood could represent a net positive ecological benefit from the FishWise Advisory. In this context, it is important to point out that the FishWise label will only lead to substantial ecological benefit if it leads to less capture of ecologically unsustainable seafood. The existence of a well-integrated international seafood market would suggest that this outcome is highly unlikely.

Notably, the lack of reduction in red labeled seafood sales presents a significant obstacle to change. Profit-driven retail grocery stores are likely to continue stocking red labeled seafood as long as consumer demand exists. All of the 20 top U.S. supermarkets, for example, reportedly sell large quantities of the most environmentally unsustainable seafood [53], a clear indicator that such consumer demand exists [5]. Consumers who purchase red labeled seafood may not derive any direct utility from consuming environmentally sustainable seafood, and in fact, might experience significant dis-utility if asked to purchase a substitute [15].

For conservation organizations and other groups seeking to reduce overfishing, one implication of this research is that a much better understanding is needed of whether and when eco-labels achieve their goals before continuing to rely so heavily on changing household consumption patterns as a primary conservation tool for wild fisheries. We recommend performing additional research in areas where consumers have not had as much prior information on seafood sustainability, conducting research on other labeling schemes to identify those that have the desired effect of increasing the sales of the most environmental sustainable seafood

[15] For example, a consumer could have planned a dinner menu around a particular type of seafood such as Chilean sea bass. That consumer would have to alter the menu if an acceptable alternative was unavailable - whether because of taste, quality or price.

and decreasing sales of the least environmentally sustainable seafood, and replicating these sorts of quasi-natural experiments over longer time frames, given that it may take many years for people to change their behavior. In addition, encouraging standard data collection procedures and data sharing agreements at retailers implementing eco-labels in order to make empirical data more readily available and suitable for rigorous statistical analysis, while creating uniform labeling standards and implementing testable, metrics-driven objectives into the design of labeling programs, would benefit future research.

Figure 1: **Store Locations**

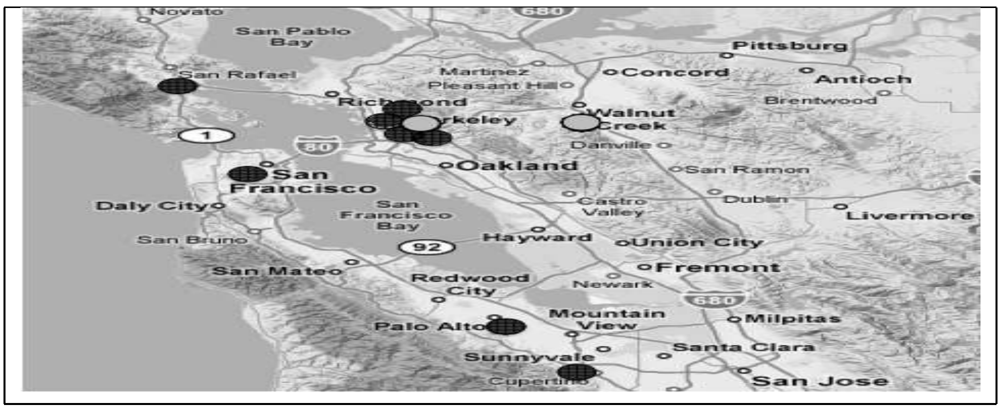

Figure 3 shows the Retailer's ten store locations. The Retailer piloted the FishWise advisory in two randomly-selected stores between February 19 - May 17 , 2006 before implementation in all stores. Locations of treatment stores are shown in blue, and locations of control stores are shown in red.

Table 1: **Store Characteristics**

	Treatment stores			**Control stores**		
	pre-treat	**treat**	**delta**	**pre-treat**	**treat**	**delta**
Weekly store sales ($)	404,707	397,769	-1.7%	338,822	326,430	-3.8%
	(125,318)	(112,912)		(120,515)	(109,707)	
Weekly meat sales ($)	30,653	29,525	-3.8%	25,954	25,408	-2.1%
	(7,977)	(6,664)		(11,542)	(10,889)	
Weekly seafood sales ($)	16,259	14,901	-9.1%	11,898	11,264	-5.6%
	(2,051)	(1,572)		(4,715)	(4,607)	
Weekly seafood sales (lbs)	732	718	-1.9%	541	551	1.9%
	(210)	(177)		(229)	(213)	
Weekly store traffic (shoppers)	14,449	14,649	1.4%	11,126	11,384	2.3%
	(3,159)	(3,349)		(2,586)	(2,532)	
Median annual HH income ($)	45,015	45,015	0.0%	78,842	78,842	0.0%
	(6,540)	(6,540)		(26,434)	(26,434)	
Number of stores	2	2		8	8	

Standard deviations in parentheses. Table 1 provides descriptive statistics of store characteristics for all ten Retailer stores for a twenty-four week period between February 19 - September 3, 2006. The pre-treatment period is twelve weeks starting on February 19, 2006 and ending on May 17, 2006. The post treatment period is twelve weeks starting on June 10, 2006 and ending on September 3, 2006. Unless noted otherwise, all figures are weekly averages. Sales and customer traffic data were obtained from the Retailer's scanner data. Median household income was obtained from U.S. Census data, which is why the median annual household income is constant across both the pre-treatment and treatment periods.

Table 2: **Summary Statistics**

	Treatment stores			Control stores		
	pre-treat	**treat**	**delta**	**pre-treat**	**treat**	**delta**
Sales by weight (%)						
Green	68.9	60.8	-8.2%	60.1	62.0	1.9%
	(5.4)	(10.3)		(10.8)	(10.4)	
Yellow	13.3	13.8	0.5%	14.8	15.3	0.4%
	(2.8)	(2.8)		(3.7)	(4.0)	
Red	17.8	25.5	7.7%	25.1	22.8	-2.3%
	(5.3)	(11.9)		(10.6)	(9.3)	
Number of choices						
Green	13.2	13.8	4.4%	11.6	13.3	14.6%
	(2.1)	(2.3)		(2.5)	(2.9)	
Yellow	9.3	10.3	10.8%	9.5	9.7	2.4%
	(1.6)	(1.8)		(2.4)	(2.6)	
Red	11.2	8.5	-24.5%	11.1	9.9	-10.7%
	(1.9)	(2.1)		(2.5)	(2.9)	
Label characteristics (%)						
Low mercury	56.7	55.2	-1.6%	53.5	50.3	-3.2%
	-4.5	-3.4		-6.4	-5.6	
On sale	30.4	28.5	-1.9%	31.6	27.2	-4.5%
	-6.0	-3.5		-7.9	-5.9	
Wild	52.2	55.2	2.9%	53.9	57.5	3.7%
	-5.1	-4.5		-6.4	-5.6	
Caught in the U.S.	36.6	41.2	4.6%	33.9	40.9	7.0%
	-2.6	-3.8		-6.8	-6.5	
Number of observations	807	779		3,092	3,163	

Table 2 provides descriptive statistics for the data set used in the discrete choice analysis. "Pre-treat" refers to the pre-treatment period, which covers twelve weeks starting on February 19, 2006 and ending on May 17, 2006. "Treat" refers to the treatment period, which covers twelve weeks starting on June 10, 2006 and ending on September 3, 2006. All figures are weekly averages except for the number of observations, which is a total for the entire period. The number of choices refers to the number of product options available to a consumer at the point of purchase. Label characteristics refers to the percentage of products with each of these characteristics. Pricing is weighted by sales in pounds.

Figure 2: **Example of Retailer's FishWise Pin Tag**

This is an example of the Retailer's FishWise pin tag for Petrale Sole. Starting from the top left and moving clockwise, the elements of the label are: FishWise logo, symbol for the catch method (the method shown on this tag means "bottom trawl"), product name, price per pound, country of origin, and color. In the retail setting, these labels are colored; the gray sections at the top and bottom of this label would be yellow. The Retailer updated these tags weekly on Tuesday nights. Note that FishWise works with each Retailer to design this tag; the tags for each participating Retailer may have a different format or layout, but will contain the same information.

Figure 3: **Example of FishWise's Low Mercury List**

This is an example of the FishWise January 2008 low-mercury list. To be included on this list, it must be safe for a 154 pound adult to eat an eight ounce portion once a week based on Environmental Protection Agency standards and currently available data on mercury and poly-chlorinated biphenyls (PCBs). This information about mercury content was not included on the product pin tag. Instead, it was available to consumers as paper handouts at the seafood counter. To be included on this list, a product also had to be rated as either green or yellow in terms of environmental sustainability; the list does not contain any red-labeled products.

Figure 4: **Average Weekly Store Sales by Seafood Type**

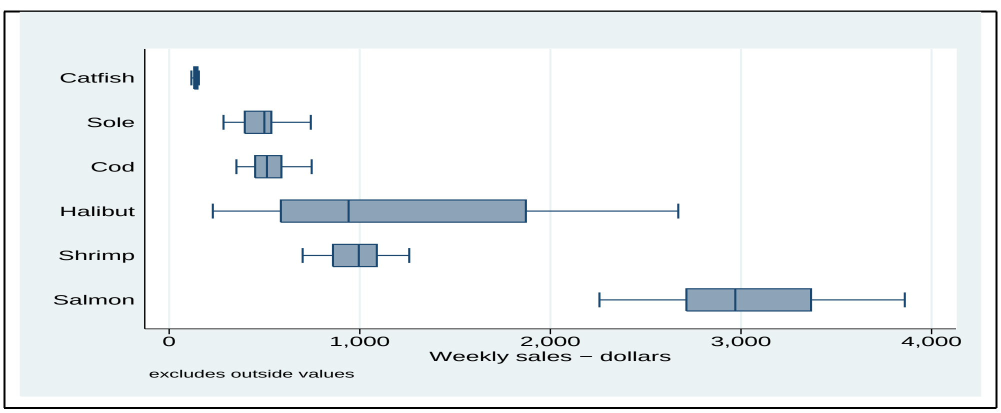

Figure 4 shows average weekly store sales (in dollars) by seafood type during the twelve-week pre-treatment period (February 16, 2006 - May 16, 2006). The lower and upper boundaries of the boxes represent 25th and 75th percentile, respectively. Lower and upper lines represent lower and upper adjacent value.

Figure 5: **Product Mix by Label Color and Store**

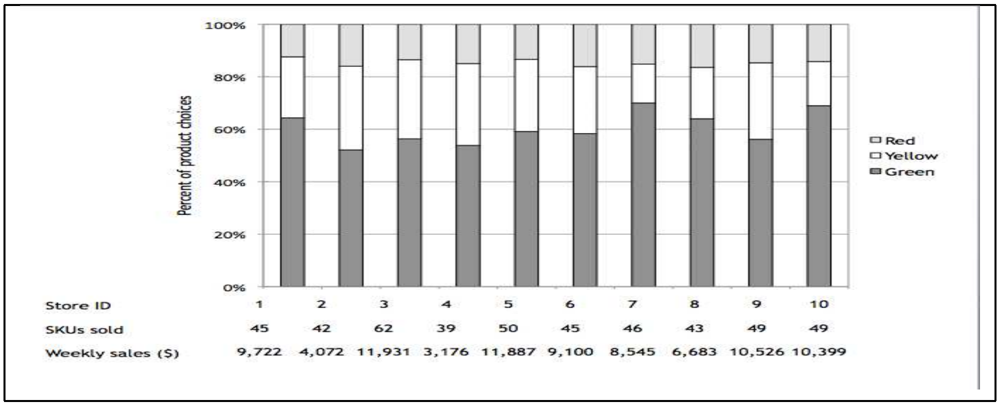

Figure 5 shows the average product mix, number of product choices (SKUs) and average weekly sales for Retailer stores during the pre-treatment period.

Table 3: **Pricing Comparison for the Pre-treatment and Treatment Periods**

	Pre-treat	**s.d.**	**Treat**	**s.d.**	**p val**
Pricing - treat stores (average, $)					
Overall	13.41	1.02	14.43	1.37	0.11
Green	13.22	1.38	14.54	1.05	0.05
Yellow	13.60	2.25	13.93	1.81	0.75
Red	12.91	2.23	13.90	2.39	0.41
Thailand farmed tiger shrimp	10.48	1.02	10.68	0.46	0.63
USA wild king salmon fillet	23.12	1.55	15.99	0.00	0.00
USA wild halibut steak	11.66	0.47	13.92	1.15	0.00
USA wild petrale sole fillet	15.65	0.22	15.99	0.01	0.00
USA wild halibut fillet	14.34	0.93	16.94	1.13	0.00
Vietnam farmed basa basa fillet	7.89	0.87	7.76	0.93	0.77
USA wild cod fillet	9.99	0.00	9.98	0.02	0.33
Canada wild pacific red snapper	8.99	0.00	8.99	0.00	0.32
Equador farmed tilapia fillet	9.98	0.90	7.79	2.55	0.04
USA farmed trout whole	4.99	0.00	3.39	0.90	0.01
Pricing - control stores					
Overall	13.09	1.21	13.81	1.42	0.03
Green	12.10	1.64	13.74	1.81	0.00
Yellow	13.44	1.40	13.77	1.69	0.41
Red	14.22	3.17	13.63	1.64	0.36
Thailand farmed tiger shrimp	10.39	1.02	10.63	0.46	0.24
USA wild king salmon fillet	22.95	1.38	16.86	1.57	0.00
USA wild halibut steak	11.58	0.46	13.78	1.13	0.00
USA wild petrale sole fillet	15.62	0.20	15.99	0.01	0.00
USA wild halibut fillet	14.17	0.92	16.79	1.12	0.00
Vietnam farmed basa basa fillet	7.81	0.82	7.84	0.91	0.93
USA wild cod fillet	9.99	0.00	9.99	0.01	0.06
Canada wild pacific red snapper	8.99	0.00	8.99	0.01	0.17
Equador farmed tilapia fillet	9.96	0.83	8.01	2.40	0.00
USA farmed trout whole	4.99	0.00	4.09	1.02	0.00

Table 3 compares pricing for the twelve week pre-treatment and twelve week treatment periods for treatment and control stores. The products listed in the table were the ten highest revenue products sold in the pre-treatment period, representing approximately 54% of seafood sales across all ten stores in an average week. This table is based on a twelve-week period pre-treatment and a twelve-week treatment period. Weighted averages were first computed for each week, and then the simple average was taken across weeks.

Table 4: **Average Treatment Effect (FE Estimator)**

Dependent variable: ln (pounds) sold of seafood i in store s during period t.

	(1)	(2)	(3)	(4)	(5)
Treatment period dummy	-0.0201	0.1438	-0.0488	-0.0741	-0.1386
	(0.0515)	(0.1503)	(0.1678)	(0.1754)	(0.1898)
Treatment effect	-0.1298	-0.1187	-0.1321	-0.1451	-0.1530*
	(0.0818)	(0.0818)	(0.0820)	(0.0825)	(0.0759)
Ln(price)			-0.0228	-0.0197	-0.0114
			(0.8056)	(0.8031)	(0.8013)
Promotion indicator			0.6297***	0.6285***	0.6247***
			(0.0716)	(0.0728)	(0.0726)
Fish share (of meat)				1.6773**	1.6536**
				(0.6444)	(0.5949)
Mercury list share					-0.6803**
					(0.2695)
Yellow share					-0.0068
					(0.3209)
Red share					-0.7017
					(0.5613)
Constant	4.8230***	5.1287***	5.0106**	4.7395*	5.2898**
	(0.0217)	(0.0731)	(2.0076)	(2.1042)	(2.0524)
Week by seafood type		yes	yes	yes	yes
Discount dummy			yes	yes	yes
Observations	7841	7841	7841	7841	7841
r2	0.0013	0.1130	0.1574	0.1578	0.1584

Standard errors in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Table 4 reports the treatment effect of the FishWise advisory on seafood sales per fish by comparing the change in sales in treatment stores displaying the labels to changes in control stores not displaying the labels. All coefficient estimates represent results of applying a fixed effects estimator to an unbalanced panel data set in which the panel variable is a store-product and the data set covers twenty-four weeks of weekly data.

Table 5: **Treatment Effect by Label Color (FE Estimator)**

Dependent variable: ln(pounds) sold of seafood i in store s during week t.

	(6)	(7)	(8)	(9)	(10)
Green: treatment period	0.1023	-0.1027	-0.3125	-0.3080	-0.3907
	(0.0763)	(0.2293)	(0.2075)	(0.2115)	(0.2380)
Yellow: treatment period	-0.2045***	-0.3780*	-0.5471**	-0.5433**	-0.6243**
	(0.0526)	(0.1904)	(0.1722)	(0.1776)	(0.1998)
Red: treatment period	-0.0184	-0.1727	-0.3928**	-0.3904**	-0.4701**
	(0.0694)	(0.1235)	(0.1337)	(0.1375)	(0.1667)
Green: treatment effect	-0.0705	-0.0572	-0.0670	-0.0809	-0.0883
	(0.1034)	(0.1057)	(0.1286)	(0.1308)	(0.1229)
Yellow: treatment effect	-0.3233***	-0.3113***	-0.3286***	-0.3416***	-0.3490***
	(0.0606)	(0.0457)	(0.0407)	(0.0340)	(0.0330)
Red: treatment effect	-0.0705	-0.0653	-0.0774	-0.0904	-0.0993
	(0.1593)	(0.1521)	(0.1042)	(0.1015)	(0.0975)
Ln(price)			0.0534	0.0585	0.0642
			(0.8284)	(0.8253)	(0.8233)
Constant	4.8273***	5.1360***	4.8281**	4.5592*	5.0993**
	(0.0209)	(0.0716)	(2.0630)	(2.1596)	(2.1034)
Week by seafood type		yes	yes	yes	yes
Price			yes	yes	yes
Discount dummy			yes	yes	yes
Promotion dummy			yes	yes	yes
Fraction of store sales				yes	yes
Fraction low-mercury list					yes
Fraction red, yellow and green					yes
Observations	7841	7841	7841	7841	7841
r2	0.0074	0.1162	0.1599	0.1604	0.1609

Standard errors in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Table 5 reports the treatment effect of the FishWise advisory on sales of each label color by comparing the changes in treatment stores displaying color labels to changes in control stores not displaying color labels. All coefficient estimates represent results of applying a fixed effects estimator to an unbalanced panel data set in which the panel variable is a store-product and the data set covers 24 weeks of weekly data. Regression (1) contains only the covariates whose coefficients are shown. Regressions (2) - (5) contain the additional covariates listed in the table.

Table 6: **Treatment Effect by Label Color and Health Information (FE Estimator)**

Dependent variable: ln(pounds) sold of seafood i in store s during period t.

	(All products)	(Mercury safe)	(Not mercury safe)
Green: treatment period	-0.3907	-0.3718	1.5802***
	(0.2380)	(0.2752)	(0.2663)
Yellow: treatment period	-0.6243**	-0.3004	0.0000
	(0.1998)	(0.2947)	.
Red: treatment period	-0.4701**	0.0000	0.7160***
	(0.1667)	.	(0.1247)
Green: treatment effect	-0.0883	-0.0017	-0.2144
	(0.1229)	(0.1231)	(0.1880)
Yellow: treatment effect	-0.3490***	-0.4126**	-0.1961
	(0.0330)	(0.1594)	(0.4711)
Red: treatment effect	-0.0993	0.0000	-0.0775
	(0.0975)	.	(0.0643)
Ln(price)	0.0642	-0.3590	-0.8564
	(0.8233)	(1.1259)	(1.3675)
Constant	5.0993**	6.9037**	6.8582
	(2.1034)	(2.3976)	(3.7900)
Observations	7841	3516	4325
r2	0.1609	0.1547	0.2324

Standard errors in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Table 6 reports the treatment effect of the FishWise advisory on sales of seafood by label color and whether the seafood was included on the low mercury list by comparing the changes in treatment stores displaying the labels to changes in control stores not displaying the labels. Specification (1), the base case, is the same as regression (5) in Table 5. "Mercury/PCB safe" means the product was included in a list of low mercury seafood displayed on a poster to the side of the seafood counter.

Figure 6: **Weekly Sales by Color Seafood in Paired Treatment and Control Store**

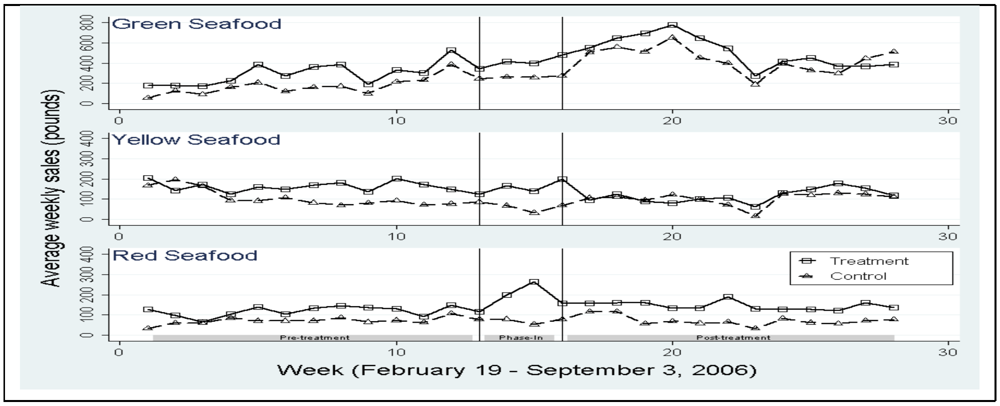

Figure 6 shows total weekly sales for store five (treatment) and store one (control). We present these two stores, rather than an average across all control and treatment stores, to facilitate a visual comparison of the trends. The graph covers 28 weeks between February 19, 2006 - September 3, 2006. The twelve-week pre-treatment period, during which neither store had implemented the FishWise Advisory, is to the left of the first vertical line. The twelve-week treatment period, during which store five had implemented the Advisory, is to the right of the second vertical line. The four-week period between the two vertical lines is the time that it took for the Retailer to phase in the FishWise Advisory.

Table 7: **Robustness Checks I (FE Estimator)**

Dependent variable: ln(pounds) sold of seafood i in store s during period t.

	(1)	(2)	(3)	(4)	(5)
Green: treatment period	-0.3907	-0.5959**	-0.3140	-0.3088	0.2917
	(0.2380)	(0.1485)	(0.2649)	(0.2593)	(0.1990)
Yellow: treatment period	-0.6243**	-0.8682***	-0.6348**	-0.6239***	-0.1965**
	(0.1998)	(0.1327)	(0.2310)	(0.1838)	(0.0699)
Red: treatment period	-0.4701**	-0.8256***	-0.4543**	-0.4595***	0.0000
	(0.1667)	(0.0914)	(0.1771)	(0.1377)	.
Green: treatment effect	-0.0883	-0.1637	-0.1137	-0.0958	0.0619
	(0.1229)	(0.1414)	(0.1271)	(0.1376)	(0.1362)
Yellow: treatment effect	-0.3490***	-0.3356***	-0.3535***	-0.3502***	-0.3050
	(0.0330)	(0.0385)	(0.0434)	(0.0392)	(0.2191)
Red: treatment effect	-0.0993	-0.0447	-0.1049	-0.1394	-0.0550
	(0.0975)	(0.0835)	(0.0968)	(0.0945)	(0.0834)
Ln(price)	0.0642	0.2570	0.3151	0.0669	-0.7947
	(0.8233)	(1.1510)	(0.9902)	(0.7715)	(1.1047)
Constant	5.0993**	3.4864	3.8177	4.2992*	5.7599*
	(2.1034)	(2.7282)	(2.8292)	(1.9875)	(2.8590)
East Bay stores only		yes			
Drop most dissimilar stores			yes		
Sixteen weeks of data				yes	
Eight weeks of data					yes
Observations	7841	4590	6466	5257	2706
r2	0.1609	0.1805	0.1669	0.1753	0.1827

Standard errors in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Table 7 contains alternative specifications to evaluate the robustness of the parameter estimates for the treatment effect of each color label. Specification (1), the base specification, is the same as specification (5) from Table 5, in which we applied a fixed effects estimator to an unbalanced panel data set in which the panel variable is a store-product and the data set covers twenty-four weeks of weekly data. Regressions (2) - (5) contain the additional variations listed in the table. Specification (2) includes only East Bay stores. Specification (3) drops the two stores with the lowest seafood sales as a fraction of total store sales. Specification (4) covers sixteen weeks of weekly data. Specification (5) covers eight weeks of weekly data.

Table 8: **Robustness Checks II (DID with Pooled OLS)**

Dependent variable: ln(pounds) sold of seafood i in store s during period t.

	(1)	(2)	(3)	(4)	(5)
Green: treatment period	-0.3923***	-0.4076	-0.5515**	-0.5680**	-0.7018**
	(0.1186)	(0.2707)	(0.2787)	(0.2788)	(0.2835)
Yellow: treatment period	-0.7573***	-0.7262***	-0.8784***	-0.8948***	-1.0287***
	(0.1228)	(0.2706)	(0.2784)	(0.2792)	(0.2832)
Red: treatment period	-0.6001***	-0.4501*	-0.6956***	-0.7122***	-0.8464***
	(0.1211)	(0.2537)	(0.2673)	(0.2681)	(0.2728)
Yellow: treatment store	-0.0951	-0.0860	-0.0683	-0.0684	-0.0689
	(0.1152)	(0.1129)	(0.1089)	(0.1089)	(0.1090)
Green: treatment store	-0.0150	-0.0292	-0.0403	-0.0406	-0.0422
	(0.1097)	(0.1039)	(0.1017)	(0.1017)	(0.1017)
Green: treatment effect	-0.0619	-0.0197	-0.0412	-0.0469	-0.0714
	(0.0973)	(0.0913)	(0.0904)	(0.0916)	(0.0931)
Yellow: treatment effect	-0.2800**	-0.2979**	-0.3254***	-0.3315***	-0.3567***
	(0.1218)	(0.1196)	(0.1170)	(0.1179)	(0.1200)
Red: treatment effect	-0.1456	-0.1471	-0.1545	-0.1604	-0.1868
	(0.1154)	(0.1160)	(0.1132)	(0.1139)	(0.1159)
Ln(price)			1.8000**	1.8037**	1.8215**
			(0.8672)	(0.8677)	(0.8673)
Constant	-0.2644	0.0488	-2.3501	-2.4157	-2.8574
	(0.4181)	(0.4740)	(2.5669)	(2.6008)	(2.6210)
Week by seafood type		yes	yes	yes	yes
Price			yes	yes	yes
Discount dummy			yes	yes	yes
Promotion dummy			yes	yes	yes
Fraction of store sales				yes	yes
Fraction low-mercury list					yes
Fraction red, yellow and green					yes
Observations	4856	4856	4856	4856	4856
r2	0.4849	0.5351	0.5514	0.5514	0.5519

Standard errors in parentheses: * p<0.10, ** p<0.05, *** p<0.01.

Table 9: **Robustness Checks III (DID for Wine with Pooled OLS)**

Dependent variable: ln(sales) of wine i in store s during period t.

	(1)	(2)	(3)	(4)
Treatment dummy	0.3053***	0.3053***	-0.0048	-0.0048
	(0.0753)	(0.0770)	(0.0674)	(0.0616)
Time dummy	-0.0193	-0.1539	-0.0193	-0.1539
	(0.0547)	(0.1829)	(0.0317)	(0.0933)
Treatment effect	0.0158	0.0158	0.0158	0.0158
	(0.1012)	(0.1046)	(0.0419)	(0.0396)
Constant	9.8093***	9.7741***	9.8420***	9.8068***
	(0.0381)	(0.1027)	(0.0590)	(0.0767)
Week dummy		yes		yes
Store dummy			yes	yes
Observations	240	240	240	240
r2	0.1081	0.1746	0.7374	0.8039

Standard errors in parentheses: * p<0.10, ** p<0.05, *** p<0.01. Table 9 reports the average treatment effect of the FishWise Advisory on wine sales by comparing the change in sales of wine in treatment stores to the sales of wine in control stores. All coefficient estimates represent results of applying a pooled OLS difference-in-differences estimator to a data set covering the twenty-four weeks of the pre-treatment and treatment periods. Regression (1) contains only the covariates whose coefficients are shown. Regression (2) contains additional week dummy variables. Regression (3) contains additional store dummy variables. Regression (4) contains both week and store dummy variables.

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