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Will American consumers pay more for eco-friendly labeled canned tuna? Estimating US consumer demand for canned tuna varieties using scanner data

Chin-Hwa Jenny Sun[a,*], Fu-Sung Chiang[b], Matthew Owens[c], Dale Squires[d]

[a] *Gulf of Maine Research Institute, Portland, ME 04101, USA*
[b] *Institute of Applied Economics, National Taiwan Ocean University, 2 Pei-Ning Road, Keelung 20224, Taiwan*
[c] *Environmental Policy and Social Responsibility, Tri Marine, Bellevue, WA 98004, USA*
[d] *Fisheries Resources Division, Southwest Fisheries Science Center, NOAA Fisheries, La Jolla, CA 92037, USA*

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ABSTRACT

This study estimates consumer demand for eco-friendly labeled canned tuna products in two distinct US marketing channels, conventional and natural supermarkets, to evaluate market-based incentives for conservation measures that affect fishing costs and retail prices. Using retail scanner data, this paper finds that US consumer demand for canned tuna varies depending on the species of tuna, what gear type was used, whether the can is sold in natural food or conventional supermarkets, and whether canned product is or is not certified as eco-friendly. The paper's main conclusions are that retail price premiums for eco-friendly products face upper limits due to consumer responses to higher prices, and are most effective when coupled with: (1) inelastic own-price elasticity of demand; (2) price premium signals that are transmitted from retail markets to raw material producers; and (3) limited retail consumption substitution possibilities with lower-priced conventional products that help maintain price premiums and that otherwise create conservation disincentives by increasing conventional supply. Results from this paper not only have unique implications for various forms of international tuna fisheries policy that incorporates or anticipates change in market behavior, but also could serve as a scientific reference to clarify the trade disputes.

1. Introduction

Several key questions facing fisheries sustainability are dependent on consumer response to “eco-friendly” labeling that indicates which type of fishing gear is used, and addresses bycatch, and other ecosystem impacts of the fishing method how the fishing method that the production method would interact with different level of bycatch that the ecosystem would be impacted ([1]; [2]). Are consumers in US retail markets willing to pay higher prices for eco-labeled seafood or is the increasing popularity of eco-labeling a result of increased market access? How responsive is consumer demand to eco-labeled and conventional seafood prices? How willing are consumers to substitute lower-priced conventional seafood for higher priced eco-labeled products, and at what price levels? How is the incidence (cost share) of a retail level eco-labeled price premium, or green sales tax, shared between consumers and supply chain firms? How will research concerning the development and implementation of certifications contribute to debates surrounding the wider theory of how market based incentive mechanisms can generate sustainable behavior?

Eco-labeling can create a market-based incentive for better-managed fisheries by fostering consumer demand for seafood products from well-managed stocks [3]. Eco-labels provide otherwise unobservable information to consumers about the environmental attributes of the products conveyed by the eco-label compared to those products that do not. Consumers valuing the environmental attributes conveyed by the label will shift demand towards the eco-labeled products and away from products that are not, which in turn creates a price premium and a market incentive for producers to supply these environmental attributes. Eco-labeling can also create market access. Market access can be viewed as a price premium, since the alternative is a potentially lower or even zero price when a product cannot enter a market. Empirical evidence points toward eco-labeling and certification as potentially effective in terms of meeting sustainability targets. For example, evidence suggests MSC certified fish stocks are healthier [4].

More formally, do consumers respond to information that can either supplement or serve as an alternative to traditional methods for

* Corresponding author.
E-mail addresses: jsun@gmri.org (C.-H. Jenny Sun), frank@ntou.edu.tw (F.-S. Chiang), mowens@trimarinegroup.com (M. Owens), Dale.Squires@noaa.gov (D. Squires).

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regulating environmental externalities [5]? In general, externalities are unintended and uncompensated positive or negative impacts from one consumer/producer to another. When information is incomplete and asymmetric, so that consumers have less information about environmental performance than the suppliers of seafood (vessels, supply chain firms), consumers have difficulty matching choices for eco-labeled products with their preferences, and incentives are created for vessels to harvest fish by environmentally damaging techniques or at levels exceeding the preferences of perfectly informed consumers.

Three linked economic externalities are present: (1) the familiar common resource stock externality from vessels using the resource stock as a costless input into their production process and leading to overfishing, (2) a public good ecosystem externality arising from bycatch, biodiversity loss, and ecological damage, and (3) an information externality due to incomplete or asymmetric information. Market failure, overexploitation, biodiversity loss, and economic inefficiency follow. Eco-labeling is intended to lessen the information externality in order to address the linked common resource stock and ecosystem externalities.

Eco-friendliness is not the main reason consumers purchase a product, but it can be an important consideration when choosing among competing products [2]. There is evidence that eco-friendly seafood (as indicated by labeling and production method) can create a price premium, but any market advantage conferred by an eco-label can be easily offset by a less eco-friendly product offered at a reduced price. This raises the questions of consumer responsiveness in retail markets to price differentials between products with and without labels and responsiveness to own-price changes, and the possibility of consumers to substitute conventional seafood for eco-friendly seafood, all with conservation implications.

However, the retail price premium may not be successfully transmitted to vessels. Without explicit mechanisms to transmit higher prices to fishers, the actual effectiveness of seafood eco-labeling schemes in promoting sustainable fish stocks, their legitimacy, transparency and openness, the integrity of their supply chains, and other direct and indirect consequences of using fisheries certification as a market-based instrument may be called into question [6–14].

There may also be information asymmetries or market power imbalances between upstream and downstream firms in a supply chain, so that consumer willingness to pay is not fully transmitted as incentives to produce eco-friendly products. Producers will respond to higher prices and/or market access by altering their production methods only if the prices producers receive in raw materials markets increase revenues.

This paper addresses questions in retail seafood markets concerning consumer willingness to pay a price premium for eco-labeled products, comparative price responsiveness of eco-labeled and conventional products, and product substitution between conventional and“eco-friendly” products. It also discusses implications of eco-labeling for conservation and the bearers of the incidence of the price premium or related environmental retail sales tax that internalizes stock and ecosystem externalities to provide better understanding and knowledge of the market place. The paper evaluates the US retail market for canned tuna by generating price elasticities for the period from September 13, 2008 to September 3, 2011. The paper touches upon, but does not resolve, three other questions: whether consumer willingness to pay is transmitted through the supply chain to producers and whether the prices producers receive in raw materials markets are price-responsive and how producers respond.

This paper estimates the price premium and price elasticity associated with eco-labeled canned tuna consumed in the US. These metrics have major policy implications for the global tuna fishery, that directly affect fisheries management, international regulations, catch quota levels, fishing effort, and gear types, etc. Further, the price incentives generated by eco-labeling effects behavior at the retail market and create conservation incentives via demand spillover effects are demonstrated. The motivations and questions are described in Section 1. Section 2 discusses methods, notably, a review of relevant literature, US market demand and market delineation, data, and model. Section 3 presents empirical results. Section 4 discusses these results and their policy implications. The concluding remarks are given in the last section.

2. Methods

2.1. Relevant literature review and background

Existing empirical research shows that seafood eco-labels are associated with shifts in market demand from moderate to more sustainable choices and willingness to pay for eco-labeled seafood [15–18]. These studies show that eco-labeling and certification have market impacts, can be associated with willingness to pay, and can potentially contribute to the promotion of fisheries management that achieves healthy fish stocks and minimizes environmental impacts [12,19–21]. However, none evaluate price and income elasticities, consumer substitution possibilities, or conservation implications. Most of the research uses attitudinal and knowledge surveys, consumer choice experiments, and experimental auctions, which capture consumers' stated preferences rather than actual behavior ([18] reviews the literature).

The literature on consumer demand in canned tuna markets is limited. Babula and Corey [22] estimated price elasticities of supply and demand for conventional US canned tuna products. Domestic canned tuna own-price demand elasticity was negative and inelastic at −0.3, while imported canned tuna demonstrated elastic own-price demand of −1.3. However, this study did not specify species and fishing gear (an indicator for eco-friendly in this study), and the modeling was based on tuna import and domestic production and producer price index (versus actual grocery store sales data).

Jaffry and Brown [23] modeled UK canned tuna demand using scanner data. They examined product mediums and interaction between traditional tuna in brine and oil and more recent value added tuna in sauces, versus products differentiated as eco-friendly. All products had negative and inelastic own price elasticities. Tuna in brine and sauce was a normal good, while tuna in oil was a luxury good. Both normal and luxury goods enjoy an increase in demand as the real income/expenditures of consumers increase, where the income/expenditure elasticity of demand measures the proportional increase in demand for a one percent change in real income/expenditures. If the income/expenditure elasticity of demand is greater than zero, the good is a normal. If it is greater than one, the good is a luxury good.

Babula and Corey [22] and Jaffry and Brown [23] looked at general demand for canned tuna in the US and UK, whereas Teisl et al. [16] focused on one of the first US seafood eco-labels, dolphin-safe tuna. Using monthly Nielson scanner data to test whether the dolphin-safe label on canned tuna changed consumers' purchasing decisions, they found the label increased the canned tuna market share. These findings have important implications for canned tuna eco-labels in general, but don't provide insight into different tuna species or market segments.

Conventional canned skipjack tuna is typically caught by purse seine vessels, which often use fish aggregating devices (FADs), but may also set on free-swimming schools of skipjack. Longline vessels catch conventional canned albacore tuna. Both fishing methods result in ecosystem impacts due to effects on the populations of target catch, and high levels of bycatch of finfish or mega-fauna species, such as sharks, sea turtles, and sea birds. Eco-friendly canned tuna brands are those that are differentiated on their labels due to harvest by Pole and Line gear (P & L), a capture method with substantially lower bycatch rates than FAD purse seines or longlines. Canned skipjack differentiated as FAD-free, or free school on the label, and which has substantially lower bycatch than FAD-caught, has only recently entered US markets, but was not included in this analysis.

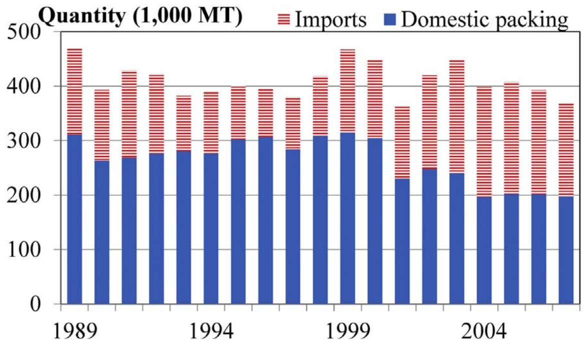

Fig. 1. Supply of canned tuna in U.S. (in net weight).

2.2. US market demand and market delineation for canned tuna

The US is the world's largest consumer of canned tuna (as a country, the European Union is larger as a block). Tuna consumption annually fluctuated between 350,000 and 450,000 t from 1989 through 2007 (Fig. 1). Consumption was lowest in 2001, and United States domestic production has remained at a low level since 2000, which has been partially replaced by an increase in imports. Approximately 70% of canned tuna in the US is sold in grocery retailers, leading to the use of grocery scanner data as the basis for this study.

The majority of US canned tuna is produced in Thailand due to global factors of production and international trade agreements that favor particular trade flows and the Bangkok market leads global pricing [24]. Although Thailand demonstrates market leadership, supply and demand are very global, with strong market integration and price uniformity across all countries. Importantly, price flexibility (the extent to which price changes when catches change) of the raw tuna material for canning in Bangkok is estimated to be inflexible [25], meaning that an increase in tuna landings can lead to prices that decrease less, proportionately, than the rise in the quantity of tuna landed. As a result of inflexible prices in the market for tuna raw material, increases in landings are associated with revenue increases, and create an incentive for fishermen to expand fishing capacity. Given this relationship between market trends and fishing behavior, market-based, ecosystem management may be a desirable avenue through which to generate more sustainable behavior. In the context of the global tuna fishery, it is important to identify if the price of eco-labeled canned tuna responds to demand conditions (particularly in the US) in order to build up integrity within the supply chain.

Another important trend, and one this study seeks to better understand, is the increasing demand among US consumers, retailers, and restaurants to purchase seafood that is produced sustainably. In 2011, 15 of the top 20 (by overall sales) North American retailers and 5 of the top 10 North American food service companies had established sustainable seafood commitments. Marine conservation efforts can result in increased prices for seafood by constricting supply in order to avoid overexploitation of target and non-target species, and/or increased operational costs for producers to comply with management measures or implement gear changes. Confirmation of consumer demand and willingness to pay for increases in seafood prices would provide convincing evidence that conservation through shifts in production methods and reduced bycatch not only has ecosystem benefits, but also increases revenues and hence, profits and resource rent, and thereby creates market-based conservation incentives.

For canned tuna, canned albacore is often steak-like, whereas canned skipjack is typically more watery and flaky. Based on product attributes and price, we can assume that consumer willingness to pay in the US is higher for a premium product. However, there is no known literature showing if consumer willingness to pay is higher for a product of similar quality that is marketed as eco-friendly.

In France, the marketing margin for 1 kg of canned yellowfin tuna in brine sold by supermarkets to consumers is about 4.99 €, whereas their cost including insurance and freight is only 3.17 € per kg. This exhibits double or triple marginalization [26]. In the U.K., canned tuna in brine, oil, and sauce all demonstrated negative and inelastic own-price elasticities, meaning that as price increases there is a proportionally smaller decrease in sales, and hence an increase in revenue [23]. Therefore, much of the European market demonstrates a consumer willingness to pay for tuna price increases.

Major retail grocery companies in the U.K. (e.g., Sainsbury's, Tesco, Waitrose) have led in promoting eco-friendly P & L-caught canned tuna, but the trend is also growing in the US. Based on information gathered from an interview with one of the largest eco-friendly canned seafood brands in the US, it is estimated that in 2007 approximately 500 natural and gourmet foods grocery stores carried P & L canned tuna, whereas today roughly 2,500 natural and gourmet foods grocery stores, and an additional 2,500 conventional and box grocery stores carry P & L canned tuna. This represents a 10-fold increase in 5 years. Furthermore, same-store sales of both P & L albacore and skipjack are estimated to have increased by over 4 times in the same 5-year period. Retail price premiums for P & L tuna are often in excess of $1.00 per can over conventional brands, yet increased market penetration and sales demonstrate a consumer willingness to pay for more environmentally responsible products.

The implications of eco-labels are important for fishery management as management bodies, in addition to fishermen, incorporate market incentives into their decision makings (there are five intergovernmental Tuna Regional Fisheries Management Organizations (RFMOs), in this case). Sun et al. [27] built a case for incorporating economic considerations into management by examining the economic trade-offs between the purse seine and longline tuna fleets targeting yellowfin and bigeye tuna in the eastern Pacific Ocean. Both tuna species are caught at sizes too small to take advantage of their individual growth and the higher prices obtained for large fish in the sashimi market. Sun et al. [27] showed that by incorporating market incentives, in this case the premium obtained by large fish in the sashimi market, managers can balance the economic and biological trade-offs so that economic value could increase while the spawning biomass of both species recovers to target levels. In one scenario, the study demonstrated that by reducing effort in the purse-seine fleet by 26.3%, via a per-ton compensation system between the purse-seine and long line fleets, the fishery as a whole could see a net economic increase of $93 million. While Sun et al. [27] focused only on tuna species managed by a single RFMO, the Inter-American Tropical Tuna Commission, the same principle can be applied across all five tuna RFMOs. Sun et al. [28] demonstrated how three tuna RFMOs, which manage the majority of the yellowfin and skipjack tuna in the Pacific and Indian Oceans, could alter global economic incentives in the market for yellowfin and skipjack tuna by coordinating multilaterally to set catch limits designed to change product prices for canning raw material. Similarly, this current paper establishes how the higher price obtained by eco-labeled canned tuna in the globally significant US retail market could affect industry-wide market incentives. Eco-labeling encourages production methods, such as P & L skipjack tuna, compatible with accompanying certification regimes and the resultant shift could change the revenues, profits, conservation, and nonmarket public benefits of the global tuna industry.

2.3. Data

Estimation of the generalized synthetic demand system (GSDS) relies on national-level, syndicated point-of-purchase grocery store scanner data collected for supermarkets in the United States. Sales data for this study was obtained from Nielsen and SPINS national level, syndicated, point-of-purchase grocery store scanner data for the period from September 13, 2008 through September 3, 2011 (156 weeks). Products included canned tuna, frozen beef, poultry, breaded fish and other canned fish, and data fields included dollar sales, volume sales, Universal Product Code (UPC), product description, and related promotional activities such as temporary price reductions. The data includes the efficient market services measure for both the percentage of brand's sales and the percentage of all commodity volume (ACV), made on a given merchandising condition, prices, and other relevant socio-economic data, that is indicated in their UPC. Based on the source and description of the canned tuna material obtained in their UPC, and the fishing practices indicated on the tuna can, products were classified by species (skipjack, albacore, and yellowfin) as being either conventional or eco-friendly.

The average price of canned albacore over the time period examined is \$5.32 per pound and is significantly more expensive than the canned skipjack average price of \$3.17 per pound. The per pound price estimate was done based on the whole round weight of each brand of the tuna can sold in supermarkets and it is usually weighted in 5 oz cans with an actual fill weight of 2.8–3.5 oz. Less than 0.2% of the total canned tuna sales in the conventional supermarkets channel in the Nielsen scanner dataset can be identified as eco-friendly canned tuna, making it impossible to specify them as a substitute for the conventional tuna can. However, their total consumption has trended up (Fig. 2a and 2b).

In comparison, about 14.81% of the canned tuna sales in the natural supermarkets channel in the SPINS's scanner dataset were identified as eco-friendly albacore canned tuna can, where consumers demonstrate a willingness to pay a \$6.46/lb premium over the conventional albacore tuna can (Table 1). However, raw fish prices for P & L albacore do not differ significantly from conventional albacore (pers. comm. with the Western Fish Boat Owners Association), meaning supply chain companies capture a significant premium.

Eco-friendly canned tuna currently comprises a very small, but fast growing proportion of the total US retail market. For example, a comparison of sales dollars and prices across conventional and natural supermarkets channels is shown in Fig. 3 for a single P & L skipjack UPC item, with the sales dollars having increased by over 20 times in the same 4-year period. Even though their total sales versus conventional canned tuna were insufficient to accurately estimate their demand elasticity, it is possible to identify a niche market for eco-friendly canned skipjack by pricing these products in both supermarkets channels based on the estimated demand elasticity of other canned tuna products.

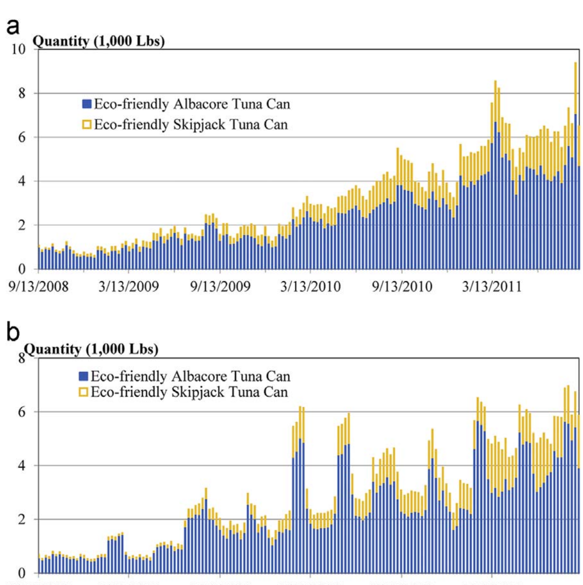

Fig. 2. Weekly Eco-friendly albacore and skipjack tuna can sales quantity in the conventional supermarkets channel (upper panel Figure 2a) and in the natural supermarkets channel (lower panel Figure 2b), respectively.

Table 1
Weekly sample statistics of canned tuna in SPINS dataset (Sep. 12, 2008–Sep. 3, 2011).

Commodity	Mean	Std. Err.	Minimum	Maximum
Quantity Sold (lbs)				
• Albacore[a]	12,450	6,219	5,410	44,839
• E. Albacore[b]	2,328	1,438	467	5,691
• Skipjack[c]	6,514	1,351	3,646	10,668
• Yellowfin[c]	8,030	2,621	4,348	20,728
Average Price (US\$/lb)				
• Albacore[a]	6.25	1.73	1.82	7.85
• E. Albacore[b]	12.71	1.83	9.49	16.80
• Skipjack[c]	6.23	0.41	5.10	7.02
• Yellowfin[c]	5.43	0.53	4.10	6.32
Share of Total Expenditure				
• Albacore[a]	38.55%	3.30%	32.47%	50.21%
• E. Albacore[b]	14.81%	6.39%	4.88%	28.32%
• Skipjack[c]	22.77%	3.46%	16.58%	35.01%
• Yellowfin[c]	23.87%	3.16%	13.83%	35.24%

[a] Indicates a canned albacore tuna product form supplied by catches from conventional tuna longline fishery.
[b] Indicates a canned Eco-friendly albacore tuna product form supplied by catches from pole and line tuna fishery.
[c] Indicates a canned product form supplied by catches from conventional tuna purse seine fishery.

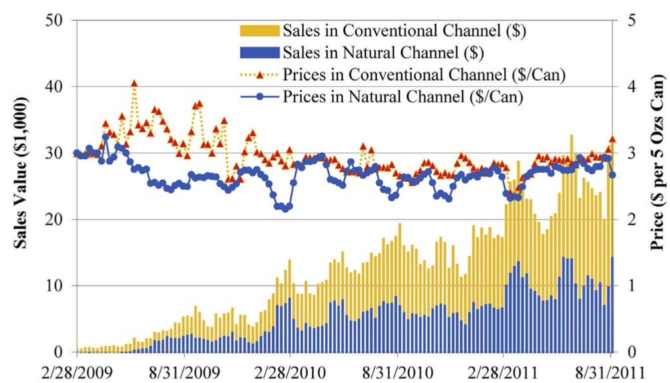

Fig. 3. Comparison of sales dollars and prices of canned pole and line skipjack tuna brand in conventional and natural channels.

2.4. Model

The generalized synthetic demand system (GSDS) [29] included four direct demand systems: (1) Almost Ideal Demand System (AIDS) [30]; (2) Rotterdam Demand System (RDS) [31,32]; (3) CBS system [33]; and (4), NBR system [34]. Barten [29] provides details. The GSDS can be specified as:

$$w_i \, dlogx_i = constant_i + (d_i + \delta_1 w_i) dlogX + \sum_j (e_{ij} - \delta_2 w_i(\delta_{ij} - w_j)) \, dlogp_j \tag{1}$$

where $w_i = p_i x_i / m$, is budget share of commodity i, x_i is optimal consumption level of commodity *i*, p_i is price of x_i, m is consumer's budget, d_i, δ_1, e_{ij}, and δ_2 are demand parameters to be estimated; and $\delta_{ij}=1$ if i=j and $\delta_{ij}=0$, otherwise.

Marginal share is $\mu_i = d_i + \delta_1 w_i$ and Slutsky terms are $\pi_{ij} = e_{ij} - \delta_2 w_i(\delta_{ij} - w_j)$, i.e., marginal share is a function of w_i and Slutsky terms are functions of w_i and w_j. When $\delta_1=\delta_2=1$, $\mu_i = d_i + w_i$ and $\pi_{ij} = e_{ij} - w_i(\delta_{ij} - w_j)$, Eq. (1) has a similar specification as AIDS in difference form. When $\delta_1=1$ and $\delta_2=0$, $\mu_i = d_i + w_i$ and $\pi_{ij} = e_{ij}$, which is CBS system. When $\delta_1=0$ and $\delta_2=1$, $\mu_i = d_i$ and $\pi_{ij} = e_{ij} - w_i(\delta_{ij} - w_j)$, which is NBR system. When $\delta_1=\delta_2=0$, $\mu_i = d_i$ and $\pi_{ij} = e_{ij}$, which is regular RDS.

The GSDS satisfies the following restrictions:

$$\Sigma_i d_i = 1 - \delta_1 \text{ and } \Sigma_i e_{ij} = 0 \text{ (adding up)}; \tag{2}$$

$$e_{ij} = e_{ji}(symmetry); \quad (3)$$

and

$$\Sigma_j\, e_{ij} = 0\ (homogeneity) \quad (4)$$

The income elasticity is:

$$\eta_{im} = (d_i + \delta_1 w_{it})/w_{it} = d_i/w_{it} + \delta_1 \quad (5)$$

The compensated price elasticities are calculated as:

$$\eta_{ij} = (e_{ij} - \delta_2 w_{it}(\delta_{ij} - w_{jt}))/w_{it} = e_{ij}/w_{it} - \delta_2(\delta_{ij} - w_{jt}) \quad (6)$$

This paper uses the methodology developed by Liang [35] and Cotterill [36] for scanner data. A theoretically consistent, linear approximate Synthetic Demand model represents the demand-side of the market [28,37]. Consistent with the approach taken by Liang [35], the first-order conditions of a general price conjectural variations model are to endogenize price and quantify strategic interaction among different types of tuna cans.

Two sets of GSDS equations are separately specified for conventional and natural supermarket channels for US consumer demand for canned albacore, skipjack and yellowfin tuna. The conventional marketing channel bundle consisted of conventional canned albacore and skipjack tuna, frozen beef, poultry, breaded fish and other canned fish, shown in the weekly sales in the Nielson's scanner dataset, and accounting for 17.41%, 18.66%, 12.46%, 12.20%, 29.80%, and 9.48%, respectively, of the weekly sales dollars (Table 2). The natural marketing channel consisted of conventional albacore, skipjack, and yellowfin tuna cans and an eco-friendly albacore tuna can.

3. Results

A set of 7 synthetic models and restricted versions of GSDS were estimated for the conventional supermarkets. Table 3 shows the logarithmic likelihood values (LLV) for each of the models. Based on the likelihood ratio test, the synthetic GSDS with free d_1 and d_2 models outperforms other restricted GSDS with higher goodness of fit with the data (Table 3). The estimate of d_1 and d_2 for synthetic model with free d_1 and d_2 are 1.18 and 1.83, respectively.

In addition, a set of 7 synthetic models and restricted versions of GSDS were estimated for the natural marketing channel with results in Table 4. The synthetic GSDS with free d_1 and d_2 models outperforms other restricted synthetic models (Table 4). The estimate of d_1 and d_2 for synthetic model with free d_1 and d_2 are 1.93 and 2.81, respectively.

Tables 5 and 6 present compensated price elasticities of demand and income/expenditure elasticities for conventional and natural supermarkets. Table 7 qualitatively summarizes many of the key results, such as the compensated or net price elasticities give pure product substitution and complementary effects without confounding by income/expenditure effects.

In conventional supermarkets, expenditure elasticities of conventional canned albacore, skipjack tuna cans and other fish can indicate as normal goods with expenditure elasticities not significantly different than one (1.077, 1.053, and 1.028, respectively) and show a proportional increase in demand quantity for a one percent change in income/expenditures (Table 5). Frozen beef and poultry are also normal goods in conventional supermarkets, with expenditure elasticities significantly less than one (η_i=0.502 and 0.879, respectively), while frozen breaded fish is a luxury good, with an expenditure elasticity greater than one (η_i=1.591) (Table 5).

Conventional albacore tuna can's net own-price elasticity is significantly negative and is not significantly different than minus one (−1.142), i.e., a unitary price elasticity, so that as price increases, decreases in quantity demand is nearly proportional, resulting in equal revenue generated. However, the conventional skipjack tuna can's net own-price elasticity is elastic (−1.188) and is significantly less than one in absolute value, so that a price increase leads to a proportionately greater decline in quantity demand and sales/revenue.

In natural supermarkets, conventional albacore, skipjack and

Table 2
Weekly sample statistics of canned tunas, frozen beef, poultry, breaded fish and other canned fish in Nielsen dataset (Sep. 12, 2008–Sep. 3, 2011).

Commodity	Mean	Std. Err.	Minimum	Maximum
Quantity Sold (lbs)				
• Albacore[a]	1,750,741	322,756	917,884	2,692,385
• Skipjack[a]	3,159,665	638,473	1,855,451	6,390,770
• Beef[b]	2,380,468	1,157,983	859,308	6,185,785
• Breaded Fish[b]	1,657,770	664,240	928,100	4,344,798
• Poultry[b]	10,373,900	3,448,744	5,080,722	18,348,500
• Other Fish[a,c]	1,231,012	245,286	824,274	2,080,589
Average Price (US$/lb)				
• Albacore[a]	5.32	0.36	4.47	6.28
• Skipjack[a]	3.17	0.21	2.43	3.50
• Beef[b]	2.83	0.17	2.34	3.29
• Breaded Fish[b]	4.02	0.28	3.24	4.47
• Poultry[b]	1.61	0.29	1.07	2.08
• Other Fish[a,c]	4.11	0.23	3.47	4.71
Share of Total Expenditure				
• Albacore[a]	17.41%	1.63%	13.92%	22.91%
• Skipjack[a]	18.66%	1.35%	15.39%	22.52%
• Beef[b]	12.46%	5.34%	6.00%	28.86%
• Breaded Fish[b]	12.20%	2.94%	7.29%	21.71%
• Poultry[b]	29.80%	3.73%	21.90%	39.61%
• Other Fish[a,c]	9.48%	1.21%	6.90%	12.78%

[a] Indicates a canned product form.
[b] Indicates a frozen product form.
[c] Other fish can include salmon, sardines, and remaining cans.

Table 3
Maximum likelihood test statistics of the generalized synthetic demand system based on conventional supermarket dataset.

System	d1	d2	Log likelihood (LLV)	Likelihood ratio test[a]
Synthetic	1.180*** (0.139)[b]	1.830*** (0.206)	1,643.68	
RIDS	0.000	0.000	1,599.52	88.32***(2)
CBS	1.000	0.000	1,555.49	176.38***(2)
AIIDS	1.000	1.000	1,636.60	14.16***(2)
RAIIDS	0.000	1.000	1,613.73	59.90***(2)
Free d1 & d2=0	0.725*** (0.137)	0.000	1,610.85	65.66***(1)
Free d2 & d1=0	0.000	1.1833*** (0.207)	1,613.73	59.90***(1)

"*", "**", and "***" indicate statistically different from zero at 10%, 5% and1% level respectively.
[a] 2*(LLV-LLV for the synthetic); degrees of freedom in parentheses.
[b] Numbers in parentheses are standard errors of parameter estimates.

Table 4
Maximum likelihood test statistics of the generalized synthetic demand system based on natural supermarket dataset.

System	d1	d2	Log likelihood (LLV)	Likelihood ratio test[a]
Synthetic	1.927*** (0.236)[b]	2.812*** (0.246)	772.658	
RIDS	0.000	0.000	721.315	102.69***(2)
CBS	1.000	0.000	728.461	88.39***(2)
AIIDS	1.000	1.000	750.577	44.16***(2)
RAIIDS	0.000	1.000	737.743	69.83***(2)
Free d1 & d2=0	0.725*** (0.137)	0.000	728.515	88.29***(1)
Free d2 & d1=0	0.000	1.18325*** (0.207)	743.433	58.45***(1)

"*", "**" and "***" indicate statistically different from zero at 10%, 5% and 1% level, respectively.
[a] 2*(LLV-LLV for the synthetic); degrees of freedom in parentheses.
[b] Numbers in parentheses are standard errors of parameter estimates.

Table 5
Scale, compensated own-price elasticity, cross-price elasticity of the generalized synthetic demand system based on conventional supermarket dataset.

Commodities	Expenditure elasticity	Compensated price elasticity (diagonal) and cross-price elasticity (off-diagonal)					
		Albacore[a]	Skipjack[a]	Beef[b]	Breaded Fish[b]	Poultry[b]	Other Fish[a]
• Albacore[a]	1.077***	−1.142***	0.325***	0.012	0.260***	0.487***	0.058
	(0.075)	(0.096)	(0.061)	(0.069)	(0.062)	(0.039)	(0.059)
• Skipjack[a]	1.053***	0.303***	−1.188***	0.052	0.120***	0.470***	0.243***
	(0.053)	(0.057)	(0.058)	(0.048)	(0.045)	(0.028)	(0.044)
• Beef[b]	0.502***	0.016	0.078	−1.178***	0.662***	0.247	0.174
	(0.131)	(0.097)	(0.072)	(0.139)	(0.077)	(0.067)	(0.069)
• Breaded Fish[b]	1.591***	0.372***	0.073	0.674***	−1.741***	0.750***	−0.241**
	(0.086)	(0.089)	(0.073)	(0.079)	(0.132)	(0.045)	(0.107)
• Poultry[b]	0.879***	0.284***	0.294***	0.103***	0.306*	−1.134***	0.146***
	(0.056)	(0.023)	(0.028)	(0.028)	(0.019)	(0.030)	(0.014)
• Other Fish[a]	1.028***	−0.964***	0.478***	0.227***	−0.309***	0.461***	−0.964***
	(0.084)	(0.036)	(0.039)	(0.026)	(0.025)	(0.061)	(0.166)

"*", "**" and "***" indicate statistically different from zero at 10%, 5% and 1% level, respectively.
[a] Indicates a canned product form.
[b] Indicates a frozen product form.

Table 6
Income, compensated own-price elasticity, and cross-price elasticity of the generalized synthetic demand system based on natural supermarket dataset.

Commodities (Canned Tuna)	Expenditure elasticity	Compensated price elasticity (diagonal) and cross-price elasticity (off-diagonal)			
		Conventional Albacore	Eco-friendly Albacore	Conventional Skipjack	Conventional Yellowfin
• Conventional	0.854***	−0.717***	0.323***	0.164***	0.230***
Albacore	(0.047)	(0.019)	(0.021)	(0.019)	(0.017)
• Eco-friendly	1.884***	0.830***	−3.106***	1.353***	0.924***
Albacore	(0.101)	(0.054)	(0.090)	(0.092)	(0.067)
• Conventional	0.688***	0.280***	0.900***	−1.910***	0.731***
Skipjack	(0.059)	(0.033)	(0.061)	(0.093)	(0.060)
• Conventional	0.974***	0.371***	0.582***	0.692***	−1.646***
Yellowfin	(0.046)	(0.095)	(0.037)	(0.056)	(0.055)

"*", "**" and "***" indicate statistically different from zero at 10%, 5% and 1% level, respectively.

Table 7
Summary of demand expenditure and price elasticities (Ela.) with respect to increase in prices by commodities and markets.

Type of Ela./Market and Product category	Expenditure Elasticity: Normal or Luxury	Own Price Ela.: Elastic, Unity, or Inelastic	Changes in Revenue: Rise or Lower	Price Incentive for Conservation: Positive or Negative	Conservation Disincentives of Increasing Price of Substitute or Complement Commodity
Conventional Supermarket					
• Albacore[a]	Normal, Unity	Unity	No Change	Neutral	(Substitute Commodity)
• Skipjack[b]	Normal, Unity	Elastic	Lower	Negative	Inelastic Substitute
• Beef[c]	Normal	Elastic	Lower	Negative	Inelastic Substitute
• Poultry[c]	Normal	Elastic	Lower	Negative	Inelastic Substitute
• Breaded Fish[c]	Luxury	Elastic	Lower	Negative	Inelastic Substitute
• Other Fish[d]	Luxury, Unity	Inelastic	Rise	Positive	Inelastic Substitute
Natural Supermarket (Canned Tuna by Species)					
• Albacore[a]	Normal	Inelastic	Lower	Positive	Inelastic Substitute
• Eco. Albacore[e]	Luxury	Highly Elastic	Lower	Negative	(Substitute Commodity)
• Skipjack[b]	Normal	Elastic	Lower	Negative	Elastic Substitute
• Yellowfin[b]	Normal	Elastic	Lower	Negative	Inelastic Substitute

[a] Indicates a canned albacore tuna product form supplied by catches from conventional tuna longline fishery.
[b] Indicates a canned product form supplied by catches from conventional tuna purse seine fishery.
[c] Indicates a frozen product form.
[d] Other fish can include salmon, sardines, and remaining cans.
[e] Indicates a canned Eco-friendly albacore tuna product form supplied by catches from pole and line tuna fishery.

yellowfin tuna cans are all normal goods, since income/expenditure elasticities are greater than zero (η_i=0.854, 0.688, and 0.974, respectively) (Table 6). However, the eco-friendly albacore can is a luxury good (η_i =1.884), so quantity demand increases more than proportionally as expenditure rises. During the economic slowdown starting from 2008, both fiscal income and expenditure dropped, lowering demand for eco-friendly albacore tuna more than proportionally.

The highly elastic own-price elasticity of eco-friendly albacore tuna can (−3.106) implies that price increases give a more than proportional decrease in quantity demanded and sales revenue. Furthermore, it is significantly higher in absolute value than the own-price elasticity of conventional albacore tuna (−0.717), which is inelastic because it is significantly less than one in absolute value. For both the conventional skipjack and yellowfin tuna cans, consumers would also reduce quantity demand more than proportional if their prices increase, since consumer own-price elasticities for each of them are all elastic (−1.910 and −1.646, respectively), but not as high as for eco-friendly albacore tuna in absolute value.

4. Discussion

US consumer demand for canned tuna varies, depending on the tuna species, whether it is sold in a natural or conventional supermarket, and whether it is considered a conventional or eco-friendly product. This paper now discusses the conservation implications of the empirical results for conventional canned skipjack in both conventional and natural supermarkets, then canned yellowfin in natural supermarkets, then conventional canned albacore in both markets, and then eco-friendly P & L-caught canned albacore in natural supermarkets.

The majority of canned tuna sold in the US by volume is conventional skipjack. Conventional skipjack's elastic own-price elasticities of demand in both conventional and natural supermarkets indicate clear economic incentives for retailers to increase skipjack demand by reducing price with sourcing cheaper FAD-caught skipjack in order to increase retail revenues and profits, since decreases in price will increase sales and revenue more than proportionally (Tables 5–7). Conversely, conservation measures that reduce supply can face pushback from retailers and supply chain firms, since sales fall proportionately more than the rise in prices and fall in revenues. The elastic own price elasticity is consistent with canned skipjack tuna's general position as a loss-leader in supermarkets, since retail revenues and sales rise with lower prices. However, because raw material demand for skipjack in Bangkok exhibits own-price elasticities near unity [28], the total revenue of the industry as a whole is not affected by price fluctuations. If capacity and catches fell the same percentage for each individual producers, like a single boat owner, revenues for existing participants would not be negatively impacted because ex-vessel markets for raw skipjack are near unitary price-quantity elasticities with stable revenues.

Skipjack is an inelastic substitute in consumption for conventional albacore and yellowfin tuna cans in both supermarkets (as indicated by positive signs of cross-price elasticities significantly less than one for conventional albacore (0.325)) in Table 5, and for conventional albacore and yellowfin tuna cans (0.164 and 0.692, respectively) in Table 6. Skipjack price increases (decreases) are met with proportionately smaller increases (decreases) in conventional albacore and yellowfin sales as consumers substitute the lower priced skipjack tuna can with higher priced albacore or yellowfin tuna cans. Here, we define X_1 and X_2 as net substitutes (complements) if an increase in P_2 leads to an increase (decrease) in compensated demand for X_1, i.e., $\partial X_1/\partial P_2 > (<) 0$ and positive (negative) cross-price elasticity for net complements (substitutes). Adverse spillover incentives emanating from retail markets are created by skipjack price increases that correspondingly increase conventional albacore and yellowfin demand and thereby generate conservation pressures. Skipjack retail price decreases have the opposite effect.

Conventional yellowfin tuna in natural supermarkets has an elastic own-price elasticity and inelastic cross-price elasticities with other canned tuna products (Table 6). Higher retail yellowfin prices more than proportionately reduce retail sales and revenues, generating positive conservation price incentives from lower supply, and less than proportionately increase demand for conventional albacore and skipjack canned tuna products, generating adverse conservation incentives. Lower prices have the opposite effect.

The unitary own-price elasticity for conventional canned albacore in conventional supermarkets means there are no economic incentives for retailers to change prices, since revenue remains constant (Tables 5–7). Price incentives are conservation neutral. However, in natural supermarkets, the inelastic own-price elasticity for conventional albacore means that price increases from lower supply in turn increase retail revenue, creating a conservation incentive (Tables 6 and 7). Conservation measures for conventional albacore in either market channel should not face revenue constraints.

Because P & L sales are still very small compared to conventional canned tuna, it was not possible to accurately model demand elasticities for eco-friendly canned albacore or skipjack in conventional markets, or eco-friendly canned skipjack in natural markets. However, in both supermarket channels, total sales of eco-friendly canned tuna increased dramatically during the study period, indicating a fast growing market for these products. Based on the price elasticities, there may be a niche price point for eco-friendly canned skipjack if priced between cheaper conventional skipjack and more expensive conventional albacore and eco-friendly albacore. Therefore, although the statistical outcomes for 3 out of 4 eco-friendly canned tuna categories analyzed in this study (eco-friendly skipjack and albacore sold in conventional versus natural supermarkets) are not available, the trends for a growing eco-labeled market are positive and could lead to greater economic incentives for conservation measures.

The price premium indicating consumer willingness to pay for eco-labeled albacore clearly exceeds that for conventionally labeled albacore in natural supermarkets. Eco-labeled albacore is a luxury good and conventionally labeled albacore is a normal good, reflecting the price premium.

The price premium coupled with high own-price elasticity of demand for eco-labeled albacore in natural supermarkets can potentially create conflicting price incentives for conservation from the bottom of the supply chain (Table 7). A price premium creates incentives to increase eco-friendly supply, but the highly elastic own-price elasticity of demand creates conflicting economic incentives for retailers to contain the eco-friendly price premium or even reduce it, since higher prices more than proportionately reduce retail sales and revenue. The high own-price elasticity potentially generates strong economic incentives to reduce eco-friendly albacore price in order to increase retail revenues. However, producers would respond to prices and/or market access by altering their production methods if the prices producers receive in raw materials markets are also price-responsive.

An additional conflicting conservation incentive arises through consumption with negative spillovers from premium-priced eco-labeled products to non-eco-labeled products. In natural supermarkets, the demand substitution between eco-labeled albacore and conventional albacore, skipjack, and yellowfin means that awarding an eco-label with a concomitant price premium spills over to non-eco-labeled products by increasing non-eco-labeled demands, as consumers substitute a lower-price non-eco-labeled product for a higher-price eco-labeled one. Inelastic substitution possibilities limit these negative spillovers for conventional albacore, skipjack and yellowfin cans (0.323 and 0.582, respectively) (Table 6). Elastic substitution facilitates negative spillovers and conservation disincentives for conventional skipjack (0.900) because the compensated substitution coefficient is not significantly different from one. These spillover demand increases would be transmitted through the supply chain to producers who do not face production constraints (e.g., Total Allowable Catches), therefore conservation disincentives emerge for these substitute conventional species, including conventional albacore that can counter the positive conservation incentives created by eco-labeled albacore.

Incidence of the eco-labeled retail price premium or a green (Pigouvian) sales tax upon consumers or supply chain firms depends upon the own-price elasticity of demand and supply. Regardless of the supply elasticity, the higher (lower) the retail own-price elasticity of demand, the greater (lower) the incidence borne by supply chain firms and the lower (greater) the incidence borne by consumers. The highly elastic own-price elasticity for eco-labeled albacore indicates that supply chain firms bear the relative incidence of the price premium. The inelastic own-price elasticities for most conventional canned products indicate that the incidence of an environmental tax would be borne by consumers.

Improved consumer information – here eco-labeled compared to conventionally labeled albacore cans in retail markets – potentially helps to mitigate the information externality linked to the resource stock and ecosystem externalities and thereby enhance conservation. However, there are clear limits to, and more complexity than initially meets the eye with, the eco-labeled price premium and the impacts of changes in retail prices upon consumer demand and conservation incentives.

5. Concluding remarks

Key results of this paper include: (1) eco-labeled products may be luxury goods that may need to target higher income retail markets; (2) price premiums for eco-labeled products are most effective when own-price elasticity of demand is inelastic; (3) conversely, high own-price elasticity of demand for eco-labeled products can be a market disadvantage, since price premiums are effectively capped and retailer incentives are to lower prices, creating conservation disincentives; (4) limited consumer substitution possibilities from eco-labeled products to conventional alternatives maintain the price premium and reach conservation goals; (5) stronger demand spillover effects (more elastic substitution possibilities) to less eco-friendly products create conservation disincentives by increasing non-eco-labeled demand; (6) eco-labeled price premiums must be transmitted from retail markets to raw material markets to create effective conservation incentives; (7) raw material markets must be price sensitive for retail price signals and conservation incentives to reach raw material producers; (8) consumers bear the incidence of the eco-labeled price premium or environmental sales taxes when own-price demand elasticities are inelastic and supply chain firms bear the incidence when elastic; and (9) if eco-labeled products are luxury goods, they may only appeal to higher income groups and be less effective than normal goods in addressing the information externality and linked production and ecosystem externalities, since the price signal and incentives arise from a more limited market than with a normal good.

The paper's main conclusions are that retail price premiums for eco-friendly labeled products face upper limits due to consumer responses to higher prices, and are most effective when coupled with: (1) inelastic own-price elasticity of demand; (2) price premium signals that are transmitted from retail markets to raw material producers; and (3) limited retail consumption substitution possibilities with lower-priced conventional products that help maintain price premiums and that otherwise create conservation disincentives by increasing conventional supply. Results from this paper have unique implications for various forms of international tuna fisheries policy that anticipates change in market behavior, and could serve as a scientific reference to clarify the trade disputes.

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References

[1] M.J. Kaiser, G. Edwards-Jones, The role of ecolabeling in fisheries management and conservation, Conserv. Biol. 20 (2) (2006) 392–398. http://dx.doi.org/10.1111/j.1523-1739.2006.00319.x.
[2] T. Ward, B. Phillips, Seafood ecolabeling, in: R.Q. Grafton, R. Hilborn, D. Squires, M. Tait, M. Williams (Eds.), Handbook of Marine Fisheries Conservation and Management., Oxford University Press, Oxford, 2010, pp. 608–617.
[3] C. Roheim Wessells, K. Cochrane, C. Deere, P. Wallis, R. Willmann, Product Certification and Ecolabelling for Fisheries Sustainability, Food and Agriculture Organization of the United Nations, 2001 83 pages FAO Fisheries Technical Paper No. 422 ⟨ftp://ftp.fao.org/docrep/fao/005/y2789e/y2789e00.pdf⟩.
[4] N.L. Gutiérrez, S.R. Valencia, T.A. Branch, D.J. Agnew, J.K. Baum, P.L. Bianchi, J. Cornejo-Donoso, C. Costello, O. Defeo, T.E. Essington, R. Hilborn, D.D. Hoggarth, A.E. Larsen, C. Ninnes, K. Sainsbury, R.L. Selden, S. Sistla, A.D.M. Smith, A. Stern-Pirlot, S.J. Teck, J.T. Thorson, N.E. Williams, Eco-label conveys reliable information on fish stock health to seafood consumers, PLoS One 7 (8) (2012).
[5] M.J. Kotchen, Voluntary- and information-based approaches to environmental management: a public economics perspective, Rev. Environ. Econ. Manag. 8 (1) (2013) 276–295.
[6] E. Stokstad, Seafood eco-label grapples with challenge of proving its impact, Science 334 (2011) 746.
[7] J. Jacquet, D. Pauly, D. Ainley, S. Holt, P. Dayton, Seafood stewardship in crisis, Nature 467 (2010) 28–29.
[8] R. Hilborn, J.H. Cowan Jr., Marine stewardship: high bar for seafood, Nature 467 (2010) 531.
[9] P.B. Marko, H.A. Nance, K.D. Guynn, Genetic detection of mislabeled fish from a certified sustainable fishery, Curr. Biol. 21 (16) (2011) R621–R622.
[10] R. Froese, A. Proelss, Evaluation and legal assessment of certified seafood, Mar. Policy 36 (6) (2012) 1284–1289.
[11] D.J. Agnew, N.L. Gutiérrez, A. Stern-Pirlot, A.D.M. Smith, C. Zimmermann, K. Sainsbury, Rebuttal to Froese and Proelss "Evaluation and legal assessment of certified seafood, Mar. Policy 38 (2013) 551–553.
[12] D.J. Agnew, N.L. Gutiérrez, A. Stern-Pirlot, D.D. Hoggarth, The MSC experience: developing an operational certification standard and a market incentive to improve fishery sustainability, ICES J. Mar. Sci. 71 (2) (2014) 216–225.
[13] C. Christian, D. Ainley, M. Bailey, P. Dayton, J. Hocevar, M. LeVin, J. Nikoloyuk, C. Nouvian, E. Velarde, R. Werner, J. Jacquet, A review of formal objections to marine stewardship council fisheries certifications, Biol. Conserv. 161 (2013) 10–17.
[14] N.L. Gutiérrez, D.J. Agnew, MSC objection process improves fishery certification assessments: a comment to Christian et al, Biol. Conserv. 165 (2013) 212–213.
[15] C.A. Roheim, F. Asche, J.I. Santos, The elusive price premium for ecolabeled products: evidence from seafood in the UK market, J. Agric. Econ. 62 (3) (2011) 655–668.
[16] M.F. Teisl, B. Roe, R.L. Hicks, Can eco-labels tune a market? Evidence from dolphin-safe labeling, J. Environ. Econ. Manag. 43 (3) (2002) 339–359.
[17] E. Hallstein, S.B. Villas-Boas, Can household consumers save the wild fish? Analysis of a seafood sustainability advisory in a U.S. supermarket, J. Environ. Econ. Manag. 66 (2013) 52–71.
[18] J. Hilger, E. Hallstein, A. Stevens, S.B. Villas-Boas, Measuring Willingness to Pay for Environmental Attributes in Seafood, University of California Berkeley, CUDARE Working Papers, 2015 ⟨http://escholarship.org/uc/item/6nh0g7fg#page-20⟩.
[19] S.R. Bush, H. Toonen, P. Oosterveer, A.P.J. Mol, The 'devils triangle' of MSC certification: Balancing credibility, accessibility and continuous improvement, Mar. Policy 37 (2013) 288–293.
[20] S.M. Martin, T.A. Cambridge, C. Grieve, F.M. Nimmo, D.J. Agnew, An evaluation of environmental changes within fisheries involved in the marine stewardship council certification scheme, Rev. Fish. Sci. 20 (2) (2012) 61–69.
[21] F. Micheli, G. De Leo, G.G. Shester, R.L.G. Martone, S.E. Lluch-Cota, C. Butner, L.B. Crowder, R. Fujita, S. Gelcich, M. Jain, S.E. Lester, B. McCay, R. Pelc, A. Sáenz-Arroyo, A system-wide approach to supporting improvement in seafood production practices and outcomes, Front. Ecol. Environ. 12 (5) (2014) 297–305.
[22] R.A. Babula, Jr.R.L. Corey, US canned tuna supply and demand, J. Int. Food Agribus. Mark. 16 (2) (2004) 145–164.
[23] S. Jaffry, J. Brown, A demand analysis of the UK canned tuna market, Mar. Resour. Econ. 23 (2) (2008) 215–227.
[24] Y. Jeon, C. Reid, D. Squires, Is there a global market for tunas? Policy implications for tropical tuna fisheries, Ocean Dev. Int. Law 39 (1) (2007) 32–50.
[25] C.H. Sun, M.C. Hsieh, Analysis of price response of Taiwan tuna purse-seine fishery in the frozen tuna raw material market in Thailand, J. Fish. Soc. Taiwan 27 (1) (2000) 47–58.
[26] R. Jiménez-Toribio J.J. Garcia del Hoyo, The Spanish market for canned tuna, Workshop on Global Tuna Demand, Fisheries Dynamics and Fisheries Management in the Eastern Pacific Ocean, La Jolla, IATTC-NOAA-Fisheries, May 14, 2010.
[27] C.H. Sun, M.N. Maunder, A. Aires-da-Silva, W.H. Bayliff, Economics and conservation: increasing the economic value of the eastern pacific ocean tropical tuna fishery. in: C.H. Sun (Ed.), Proceedings of the Workshop "Global Tuna Demand and Fisheries Dynamics: Economics of the Tuna Longline and Tuna Purse-Seine Fisheries in the Eastern Pacific Ocean", Inter-American Tropical Tuna Commission-NOAA Fisheries, 2010.
[28] C.H. Sun, F.S. Chiang, P. Guillotreau, D. Squires, D.G. Webster, M. Owens, Fewer fish for higher profits? Price response and economic incentives in global tuna fisheries management, Environ. Resour. Econ. (2015) 1–16. http://dx.doi.org/10.1007/s10640-015-9971-4.
[29] A.P. Barten, Consumer allocation models: choice of functional form, Empir. Econ. 18 (1993) 129–158.
[30] A. Deaton, J. Muellbauer, An almost ideal demand system, Am. Econ. Rev. 70 (3) (1980) 312–326.
[31] H. Theil, The information approach to demand analysis, Econometrica 33 (1) (1965) 67–87.
[32] A.P. Barten, Maximum Likelihood Estimation of a Complete System of Demand Equations 1, European Economic Review, 1969, pp. 7–73 ⟨http://www.sciencedirect.com/science/article/pii/0014292169900178⟩.
[33] W.J. Keller, J. van Driel, Differential Consumer Demand Systems 27, European Economic Review, 1985, pp. 375–390 ⟨http://www.sciencedirect.com/science/article/pii/S0014292185800210⟩.
[34] P.D. Neves, Analysis of consumer demand in Portugal, 1958–1981, Memoire de maitrise en sciences economiques, Universite Catholique de Louvain, Louvain-la-Neuve, 1987.
[35] J.N. Liang, Price reaction functions and conjectural variations: an application to the breakfast cereal industry, Rev. Ind. Organ. 4 (2) (1989) 31–58.
[36] R.W. Cotterill, Scanner data: new opportunities for demand and competitive strategy analysis, Agric. Resour. Econ. Rev. 23 (1994) 125–139.
[37] C. Sun, F. Chiang, Demand analysis of tuna for the canning market in Thailand and for the sashimi market in Tokyo, Japan, CLIOTOP-IMBER Working Group 5, Nantes, France, April 12–17, 2011.