Journal of Environmental Economics and Management **43,** 339–359 (2002)
doi:10.1006/jeem.2000.1186, available online at http://www.idealibrary.com on IDEAL®

# Can Eco-Labels Tune a Market? Evidence from Dolphin-Safe Labeling[1]

Mario F. Teisl[2]

*Department of Resource Economics and Policy, University of Maine*

Brian Roe

*Department of Agricultural, Environmental and Development Economics, Ohio State University*

and

Robert L. Hicks

*Department of Coastal and Ocean Policy, The College of William and Mary*

Received July 29, 1997; revised August 16, 2000; published online August 21, 2001

In this paper we test whether the dolphin-safe labels altered consumer purchases of tuna. We also provide a partial measure of the total welfare effects of the dolphin-safe labeling policy. The results confirm our hypothesis that the dolphin–tuna controversy and the subsequent implementation of dolphin-safe labeling affected consumer behavior. Further, the paper provides market-based evidence that consumers can respond to eco-labels; the dolphin-safe label increased the market share of canned tuna. The welfare analysis provides a partial measure of society's willingness to pay to avoid personally contributing to dolphin mortality as a result of tuna fishing. 

## INTRODUCTION

The environmental characteristics of products have become increasingly important to consumers [40, 52]. Firms have responded by placing eco-labels on products that highlight the item's environmental attributes and by introducing new, or redesigned, "green" products [50]. Governments and nongovernmental organizations have also responded by organizing, implementing, and verifying eco-labeling programs that cover thousands of products in more than 20 countries [51], while international efforts to standardize environmental labeling schemes have also emerged [12, 22]. From a policy perspective, one aim of eco-labels is to educate consumers about the environmental impacts of the product's manufacture, use, and disposal, thereby leading to a change in purchasing behavior and ultimately, to a reduction in negative impacts. Further, eco-labeling policies may promote environmental objectives without production site command and control methods and are

[1] Maine Agricultural and Forest Experiment Station Number 2449.
[2] Address correspondence to: Mario Teisl, Department of Resource Economics and Policy, 5782 Winslow Hall, University of Maine, Orono, ME 04469-5782.



0095-0696/01 $35.00

seen as a way of meeting global environmental objectives while complying with international trade agreements.[3]

In order for eco-labels to achieve policy objectives, consumers must hold preferences for certain environmental amenities and respond to the information presented on eco-labels by altering purchases toward eco-labeled goods. Their widespread use suggests that eco-labeling is perceived as an effective method of altering consumer behavior. However, few studies have attempted to identify the behavioral effectiveness of eco-labeling programs. Evaluating the policy effectiveness of eco-labeling programs requires understanding how information affects market behavior. Evaluating the economic efficiency of labeling programs requires measuring the benefits and costs of such information.

In this paper we measure the policy effectiveness of dolphin-safe labeling of canned tuna by estimating a demand system for the canned protein market by using retail level data and testing whether the dolphin-safe labels altered consumer purchases of tuna. To gain insight into the efficiency effects of information we use the estimated demand system to provide a partial measure of the total welfare effects of the dolphin-safe labeling policy using the assumption that any shifts in demand resulting from the dolphin-safe labels would reflect a type of use value.[4] Our welfare measure is partial in the sense that it only captures the values of individuals who are canned tuna purchasers. Other individuals may also obtain a welfare gain due to the increased protection of dolphin brought about by the dolphin-safe labeling of tuna.

## I. BACKGROUND AND LITERATURE REVIEW

### *A. Labeling and Consumer Choice*

Although implementation of eco-labels is widespread, research concerning its impact and effectiveness is limited and aggregate quantitative results are rare. Much of the research has measured effectiveness either by identifying changes in consumer awareness after exposure to label information [25, 26, 55] or by asking consumers whether eco-labeling programs would affect their purchase behavior [13]. However, a change in awareness does not necessarily translate into a change in behavior [6, 49] and consumers do not necessarily follow their own purchasing assertions [2, 23].

Market-based research investigating other types of labels (e.g., nutrition labels, quality seals) has demonstrated that a change in labeling can change market behavior [38, 44]. However, the apparent effectiveness of these (non-eco) labeling programs may not be applicable to eco-labeling because these non-eco-labels

[3] The dolphin-safe label used on tuna is an example of how an eco-label can bypass trade barriers. Under the Marine Mammal Protection Act, which bans the import of tuna when incidental dolphin kills exceed certain limits, the U.S. placed an embargo on Mexican tuna in February 1991, followed by embargoes on tuna from 11 other countries. In September 1991, a panel of the General Agreement on Tariffs and Trade (GATT) agreed with Mexico that the U.S. embargo violated the GATT agreement. The Dolphin Protection Consumer Information Act, passed in 1990, enforces a dolphin-safe standard in labeling and circumvents the GATT ruling.

[4] Bockstael and Stand [5] hypothesize this value reflects a change in the moral quality of the tuna. That is, by purchasing dolphin-safe tuna, the consumer can avoid personally contributing to dolphin mortality.

provide information about the characteristics of the product. Eco-labels, like the dolphin-safe labels studied here, differentiate products with respect to characteristics of the product's production.

### B. *Information and Environmental Valuation*

It has been well established in the stated-preference literature that the provision of information affects the value that a survey respondent places upon an environmental commodity [1, 3, 8]. The issue for researchers in this area is providing the appropriate amount of information such that respondents have a clear definition of the public good they are supposed to value without affecting the underlying preferences or causing certain information biases [14]. That is, the information set used by the respondent to value the commodity of interest should reflect the information set that would be invoked during the choice process in a true market, if such a market existed for the commodity in question. The availability of eco-labeling turns this concern about appropriate information disclosure on its side. Instead of treating environmental information as something that must be controlled within a survey instrument so as not to bias resulting value estimates, eco-labeling makes information disclosure a policy variable which may be used to achieve certain social objectives. Effectively, labeling decreases the search cost for the information and may signal the importance of the environmental information. Hence, labeling may affect behavior by influencing the number of attributes that a consumer considers during a choice occasion. Furthermore, labeling may affect the implicit weights that consumers assign to each attribute. Rather than trying to minimize valuation biases due to information, regulators may find it socially optimal to supply environmental information via labeling such that market behavior is affected.

### C. *The Tuna–Dolphin Issue*

Canned tuna is the most important seafood product in the United States in terms of quantity consumed [48]. Much of this tuna comes from the Eastern Tropical Pacific (ETP hereafter), which accounts for almost one-fourth of the world's tuna catch [41]. It is well known that dolphins often associate with large yellowfin tuna in the ETP. With adoption of purse seine technology[5] approximately 40 years ago, dolphins have been targeted by fishermen in the ETP as a way of finding and netting tuna. Once located, fishermen capture tuna schools by encircling the dolphins with the seine, tightening the seine, and then hauling the tuna onboard. Dolphins can be killed during the process, and during the early years of purse seining no industry-wide effort was made to mitigate dolphin deaths.

From 1960 to 1972 the National Research Council estimates that on average more than 100,000 dolphins were killed each year by the U.S. tuna fleet [41] and, in the early 1970s, biologists warned that commercial tuna operations in the ETP threatened dolphin populations. However, several governmental initiatives helped decrease dolphin mortality. The Marine Mammal Protection Act was passed in

[5] The seines used in the ETP are very large nets, approximately 1 mile long and 600 feet deep. The purse seine technology involves encircling the tuna with this net, closing the bottom of the net with a purse line, and hauling the catch onboard [41].

1972 and by 1975, in response to an amendment to the Marine Mammal Protection Act, the U.S. tuna fleet began preventive measures aimed at reducing dolphin kills. The 1988 reauthorization of the Marine Mammals Protection Act insured that there was full observer coverage on U.S. flag vessels. The observers documented if dolphins were encircled or killed as a result of fishing operations and provided the means to eventually institute a dolphin-safe labeling and verification program. Many of the member nations of the Inter-American Tropical Tuna Commission also instituted or expanded their own observer programs in subsequent years. Consequently, the National Marine Fisheries Service and the Inter-American Tropical Tuna Commission were able to verify dolphin related activities for each vessel including logbook data each time a vessel set its net in the water (commonly referred to as "a set"). The cumulative effect of these changes in terms of dolphin mortality has been dramatic. Dolphin deaths due to tuna fishing dropped to 25,000 in 1991 [41], with current mortality levels of less than 5000 per year [43].

Also during the late 1980s consumers became aware that the harvest of yellowfin tuna in the ETP caused the incidental mortality of dolphins. Media attention to the issue spawned significant controversy and, eventually, calls for consumer boycotts of canned tuna. The high-water mark of media attention and public concern coincided with the national televising of the Sam La Budde (Earth Island Institute) video which showed dolphins dying as a result of fishing operations in the ETP. The three largest tuna canners in the U.S. market announced a dolphin-safe labeling policy in April 1990 [45]. Other canners quickly followed. The U.S. government responded by passing the Dolphin Protection Consumer Information Act of 1990 which mandates that tuna products cannot be labeled as "dolphin safe" unless dolphins were not used to capture tuna for the entire fishing trip, as verified by a sanctioned observer aboard the boat. The combination of U.S. laws and embargoes in effect closed the U.S. market for tuna caught using dolphins [31]. Internationally, a nonprofit wildlife conservation group began "The Flipper Seal of Approval" [52], a dolphin-safe labeling program.

The International Dolphin Conservation Program Act [43] was passed as a domestic endorsement of the La Jolla Agreement and the Panama Declaration signed by participants in the ETP tuna fishery. These agreements set quotas on dolphin kills and reduce quotas through time. Provided that producers harvest tuna in a manner consistent with these agreements, the Act also allows for the tuna from foreign producers to be imported into the United States. Under the Act, the definition of dolphin safe is now much less restrictive, allowing fishermen to encircle dolphins while capturing tuna so long as no dolphins are killed.[6] Additionally, the dolphin-safe definition applies on a set by set basis rather than for the entire trip.[7] Under the old dolphin-safe language, one set of targeting dolphins would cause all tuna caught from the trip to fail to meet the dolphin-safe definition.

Also during the late 1980s there was a significant change in the quality of canned tuna associated with the change in tuna harvesting techniques. Tuna caught in association with dolphins tends to be large yellowfin tuna that is ideally suited for

[6] If the Secretary of Commerce finds that fishing activities are "having a significant adverse impact on any depleted stock," producers are required to not encircle and not kill dolphins while fishing in order to meet a more restrictive dolphin-safe definition.

[7] Vessels are required to maintain a separate storage well for tuna that is dolphin safe.

canning and is of high quality [53]. As fishermen decreased fishing effort directed at dolphins, the composition of their catch changed from large yellowfin to smaller yellowfin and skipjack tunas of relatively lower quality for canning.

Evidence that consumers reacted to the dolphin-safe label is difficult to find. A study by Wallstrom and Wessells [54], based on data from scanned grocery store transactions in metropolitan areas, documents an initial negative market reaction to public exposure of tuna harvesting practices in 1988 but found no significant demand effect from the labeling program. Bockstael and Strand [5] also found no significant label effect on U.S. demand for Latin American tuna imports. In addition to specific problems,[8] both studies use data with relatively short postlabel time series (30 months). However, demand shifts due to a change in labeling may occur over a relatively long time period as the label is noticed by and the information diffuses through the population [38]. In addition, consumers who notice the label may initially doubt the veracity of the label information. Anecdotal evidence suggests that it may have taken up to four years for consumers to gain full confidence in the dolphin-safe label. The data set used in this study has 66 months of postlabel time series, which allows testing for time dependent label effects.

## II. THEORETICAL FRAMEWORK

To provide a modeling framework to measure changes in consumer behavior and welfare due to changes in environmental information one needs to know how environmental awareness enters an individual's utility function (here defined in terms of a purchase occasion or decision). The utility evaluation can be represented by the indirect utility function

$$V^S = V(\mathbf{A}^S, \mathbf{q}, Y, \mathbf{p}), \tag{1}$$

where $\mathbf{A}^S$ denotes a vector of environmentally related assessments for $m$ products given information set $S$ (i.e., $\mathbf{A}^S = [A_1^S, \dots, A_m^S]$), $\mathbf{q}$ denotes a vector of other quality characteristics (e.g., taste or texture), $\mathbf{p}$ is a corresponding vector of prices, and $Y$ denotes income. $V^S$ is increasing in $\mathbf{q}$ and $Y$, and decreasing in $\mathbf{p}$.

The technology that extracts and translates environmental information into an assessment of a product's environmental impact can be viewed as a "household production" process by which an individual combines his or her prior environmental knowledge, cognitive abilities, time, and the environmental information presented during the purchase decision. Thus, we could model the assessment process during the purchase decision as

$$A_j^S = f(S_j, G, t_j), \tag{2}$$

where $A_j^S$ denotes the (subjectively) assessed environmental impact of purchasing good $j$ given information set $S, S_j$ is the environmental information displayed about product $j$ at the point of purchase (e.g., a dolphin-safe label on a can of

[8] A potential problem with the Wallstrom and Wessells study [54] is their approach in estimating demand (use of least squares on single-equation models without apparent testing/correcting for autocorrelation), leading to a probable omitted variable bias and misidentification of label effects. The Bockstael and Strand study [5] may be limited by trying to estimate changes in consumer demand with import/export data.

tuna), $G$ denotes the consumer's prior stock of environmental information which may include information from news accounts, firm-provided advertising, and public education campaigns, and $t_j$ denotes the time that the individual devotes to processing $S_j$.

The objective level of the environmental impact characteristics represented by the information variable $S$ is denoted by $\theta$. For example, if $S$ represents a dolphin-safe claim on a canned tuna label, then $\theta$ denotes that the production of the tuna led to no actual dolphin deaths. $\theta$ is separate from the assessment function because the individual does not observe it at the time of purchase except through the variable $S$. Although $\theta$ may be unobservable to the consumer at the time of the purchase decision, we include it within the discussion to distinguish between the factor that affects consumer decisions, $S$, and the one that ultimately determines the environmental impact of production, $\theta$.

The subject of interest is to measure the welfare effect of a change in information that accurately reflects a change in the true environmental impact of the good (e.g., the provision of dolphin-safe labeling of tuna that corresponds to a change in commercial tuna fishing practices). We begin by presenting expenditure functions under two alternative states of information. Denote

$$e(\mathbf{A}^0(\cdot), \mathbf{q}, U, \mathbf{p}) \tag{3}$$

as the expenditure function when the environmental impact of a product is at level 0 and the information about the environmental impact accurately reflects that level ($S = 0$ and reflects the state of $\theta$). Likewise,

$$e(\mathbf{A}^1(\cdot), \mathbf{q}, U, \mathbf{p}) \tag{4}$$

is the expenditure function when the environmental impact of a product is at level 1 and the information about the environmental impact reflects the new level ($S = 1$ and reflects the state of $\theta$).

Although not commonly framed as such, compensating variation (CV) measures the change in individual welfare when the qualities of a good changes (denoted as a move from $\theta = \theta^0$ to $\theta = \theta^1$) along with a corresponding change in information about the quality change ($S = 0$ to $S = 1$). During a purchase occasion, CV can be expressed as

$$\mathrm{CV} = e(\mathbf{A}^1(\cdot), U^0, \mathbf{p}^0) - e(\mathbf{A}^0(\cdot), U^0, \mathbf{p}^0), \tag{5}$$

where $U^0$ denotes the initial utility level ($q$ is dropped for simplicity).

If the change in $\theta$ is positive then $\mathrm{CV} \geq 0$. Here CV measures the maximum amount of money an individual is willing to pay to gain the better quality, given that he or she knows about the quality change (i.e., he or she has the correct information about the quality change so that he or she is free to alter consumption). Alternatively, if the change in $\theta$ is negative then $\mathrm{CV} \leq 0$, which denotes the maximum amount of money an individual must be given to accept the (known) poorer quality.

## III. THE MODEL

Typically, economists do not have complete price and quantity information for all goods and must be satisfied estimating demand systems for a subset of the universe of goods. Our analysis of the impact of the dolphin-safe label focuses on canned tuna and its substitutes. Although the data here are complete with respect to expenditures on canned tuna and its hypothesized substitutes, they do not include market-related information on all other goods. A common approach to demand estimation under this lack of information is to assume a weakly separable utility function and estimate a set of conditional demand functions which are a function of the prices of the goods of interest and of expenditures on the subset of goods.[9] A problem with conditional demand functions is that the conditional demand systems can produce welfare measures that are biased [36, 37]. However, the conditional compensating variation measure is conservative in that it always understates the true compensating variation [37].[10]

For the problem at hand, it is essential that a utility-theoretic demand model be estimated so that the relevant parameters of the underlying expenditure function can be recovered. The demand system was estimated using Deaton and Muelbauer's almost ideal demand system (AIDS) expanded to include information effects [16, 42]. The AIDS model is chosen because it satisfies the axioms of choice, allows imposition of adding up, homogeneity, and Slutsky symmetry restrictions, allows some forms of aggregation, and is integrable [15]. In addition, AIDS models have been shown to be equivalent or superior to other common demand specifications, e.g., translog [39]; log–translog, CES-transformed AIDS [10]; Rotterdam, CBS [18]; LES, indirect addilog, general dynamic AIDS, indirect translog [20]; and linearized AIDS [7].

The demand system includes canned tuna and three substitute meat products: shelf-stable luncheon meats (both sliced and deli-pouch), other canned seafood products (salmon, shrimp, and sardines), and canned red meat (beef, barbecued beef, corned beef, corned beef hash, deviled ham, potted meat spread, other meat spreads, spiced meats).[11] We do not separate canned tuna into dolphin-safe (labeled) and non-dolphin safe (unlabeled) segments because virtually all tuna marketed after 1990 was dolphin safe (labeled). That is, at no point in time is there any discernible cross-sectional variation with respect to dolphin-safe labeling.

The expanded AIDS model begins with the household's conditional expenditure (hereafter, expenditure) function

$$\log\{e_h(p, A(\cdot), \Psi, U)/K_h\} = a(p, A(\cdot), \Psi) + b(p)U, \tag{6}$$

[9] Weak separability is a necessary and sufficient condition for the existence of conditional demand functions [35].

[10] An alternative approach is to specify an incomplete system of demand equations that include equations representing the goods of interest with an additional equation representing spending on all other goods (through the construction of a composite commodity). When the demand system is integrable then this approach can be used to calculate exact welfare measures from the parameters of the incomplete demand system [33, 34]. We do not follow this approach because we lack sufficient data to construct this composite commodity.

[11] Either of two conditions allows aggregation across goods: (1) when the prices of the group of goods to be aggregated move in parallel or (2) when the utility function is weakly separable across the different groups of aggregated goods [15].

where $p$ denotes prices, $A(\cdot)$ denotes the awareness function which may be influenced by label and media-provided information, $\Psi$ denotes other demand influences (such as product seasonality), $U$ denotes utility, and $K_h$ is a general measure of household size to deflate the budget of the household to a "needs-corrected" per capita basis [15]. Here, during time $t$,

$$a(p, A(\cdot), \Psi) = \alpha_0 + \sum \alpha_i \log P_{it} + (1/2) \sum \sum \gamma_{ij} \log P_{it} \log P_{jt},$$

$$\alpha_i = \left\{ \xi_i + \tau_i T_t + \rho_{1i} M_t + \rho_{2i} V_t + \phi_i L_t + \sum \omega_j A_{jt} + \theta_{1i} iRt + \theta_{2i} R_{2t} \right\},$$

and

$$b(p) = \beta_0 \Pi P_i^{\beta_i},$$

where $T_t$ is a time trend, $M_{it}$ denotes the number of newspaper and magazine articles discussing the tuna/dolphin issue and is included to capture any changes in demand due to news media coverage of the tuna-dolphin controversy, and $V_t$ denotes a three-month time period immediately following the news release of the Sam La Budde video. $L_t$ denotes the diffusion of the label information across the population. The functional form of the label information diffusion process is modeled as a logit CDF occurring over an 18-month period. Specifically, $L_t$ is zero pre-April 1990, follows a logit probability curve until November 1991 and is equal to one afterward.[12] This S-shaped functional form is similar to others modeling information diffusion (e.g., see [9, 28]). $A_{jt}$ denotes the level of retail-sponsored advertising used to promote the $j$th good; $R_{1t}$ and $R_{2t}$ represent "religious–seasonal" indicator variables. Specifically, $R_1$ is equal to one during the months of February and March (Lent), zero otherwise; $R_2$ is equal to one during the month of December (winter holidays), zero otherwise; and $P_{jt}$ is the price of (composite) good $j$.

Taking the derivative of (6) with respect to log $P_i$ and appropriate substitution of $U$ provides the expenditure share equation for the $i$th good during time $t$,

$$W_{iht} = \xi_i + \tau_i T_t + \rho_{1i} M_t + \rho_{2i} V_t + \phi_i L_t + \sum_j \omega_{ij} A_{jt} + \theta_{1i} R_{1t} + \theta_{2i} R_{2t} + \sum_j \gamma_{ij} \log P_{jt} + \beta_i \log(X_h / K_h P^*)_t, \tag{7}$$

where $W_{iht}$ is the share of household expenditure on good $i$, $X_h$ is household expenditures on the goods in the system, and $\log P^* = a(p, A(\cdot), \Psi)$.[13]

[12] We considered two other functional forms to represent the label effect on budget shares. One specification included a dummy variable to denote the change in the information policy along with an interaction term between the time variable and the label policy dummy. With this specification both the label-dummy variable and the label–time interaction term were significant and positive, indicating a label effect. However, the parameter on the label dummy was relatively small, indicating that the effect of the label was small immediately after the labels entered the market but that the effect continued to grow over time. In the second specification, information diffusion was modeled as a log of the time trend variable. In this specification the label parameters were not significant. The presented specification allowed for the best fit of the model.

[13] Most empirical studies using AIDS models have used the Linearized AIDS model which substitutes $P^*$ with Stone's price index. Although simpler to estimate, the Linearized AIDS provides inconsistent parameter estimates [7].

A limitation often encountered by researchers is that data on market purchases are often aggregated at some level. A benefit of the AIDS framework is that, as a member of the price independent generalized log (PIGLOG) class of expenditure functions, it fulfills the conditions required for exact nonlinear aggregation. That is, the share equations and the expenditure function derived from the AIDS model can be seen as coming from a single representative household. Thus the parameters of a household's expenditure function can be (approximately) recovered even though the share equations are estimated using aggregate data.

Following Deaton and Muelbauer, the individual household share equations can be aggregated across households by multiplying $W_{iht}$ by individual household expenditure, summing over all households, and dividing by the aggregate expenditure,

$$W_{it} = \alpha_i^* + \sum_j \gamma_{ij} \log P_{jt} + \beta_i \log(X_t/P_t^*), \tag{8}$$

where $W_{it}$ is the share of aggregate expenditure spent on good $i$ in the aggregate expenditure of all households, $\alpha_i^* = \Sigma_h\{X_{ht}\alpha_i/\Sigma_h X_{ht}\}$, and $\log X_t = \Sigma_h\{X_{ht}\log(X_{ht}/k_h)/\Sigma_h X_{ht}\}$.

Deaton and Muelbauer note that one can find an aggregate index, $K$, such that $\log(\mathbf{X}/K) \equiv \Sigma_h\{X_{ht}\log(X_{ht}/k_h)/\Sigma_h X_{ht}\}$, where $\mathbf{X}$ is average household expenditure and $\mathbf{X}/K$ is the representative expenditure level. If cross-sectional data on $X_{ht}$ and $k_h$ are available then one could calculate a value for $K$. Typically, this type of data is unavailable so economists have generally approximated $\mathbf{X}/K$ with per capita "conditional" expenditures (i.e., total expenditures on the goods within the system/population). Given the above, the AIDS model provides a method of approximating the change in welfare of a "representative household" while using aggregate data.

We estimate the above nonlinear system of equations using iterated seemingly unrelated regression. We correct for potential autocorrelation by following the procedures outlined by Berndt and Savin [4, 42]. Denote the system of four share equations as

$$\mathbf{w}_t = \Pi \mathbf{Z}_t + \mathbf{v}_t, \tag{9}$$

where $\mathbf{w}_t$ is the $4 \times 1$ vector of dependent variables, $\Pi$ is the $4 \times k$ matrix of unknown parameters, $\mathbf{Z}_t$ denotes the $k \times 1$ vector of variables denoted by the right-hand side of (8), and $\mathbf{v}_t$ is the $4 \times 1$ vector of errors. Assume the vector of errors exhibits first-order autocorrelation; i.e.,

$$\mathbf{v}_t = R\mathbf{v}_{t-1} + \mathbf{e}_t, \tag{10}$$

where $\mathbf{R}$ is a $(4 \times 4)$ matrix of unknown parameters, $r_{ij}$ $(i, j = 1, \dots, 4)$, and the $\mathbf{e}_t$ are independent, normally distributed random vectors with mean vector zero and covariance matrix $\Omega$. Because of the adding up condition, ($\zeta'\mathbf{w}_t = 1$, where $\zeta$ is a $4 \times 1$ vector of ones) one of the share equations is dropped during estimation. The adding up condition implies $\zeta'\mathbf{v}_t = 0$, and since $\mathbf{v}_{t-1}$ and $\mathbf{e}_t$ are independent, it also follows that $\zeta'\mathbf{R} = k$, where $k$ is an unknown constant, and $\zeta'\mathbf{e}_t = 0$. Deleting the last equation from (9) and (10) gives

$$\mathbf{w}_t^* = \Pi^* \mathbf{Z}_t + \mathbf{v}_t^* \tag{11}$$

and

$$\mathbf{v}_t^* = \mathbf{R}^* \mathbf{v}_{t-1} + \mathbf{e}_t^*, \tag{12}$$

where $\mathbf{w}_t^*$, $\mathbf{v}_t^*$, and $\mathbf{e}_t^*$ are equal to $\mathbf{w}_t$, $\mathbf{v}_t$, and $\mathbf{e}_t$ with the last element removed and $\Pi^*$ and $\mathbf{R}^*$ are equal to $\Pi$ and $\mathbf{R}$ with the last row removed. The above system of equations cannot be estimated because the $\mathbf{R}^*$ matrix is not square ($3 \times 4$). However because $\zeta' \mathbf{v}_t = 0$, we can rewrite $\mathbf{R}^*$ as $\underline{\mathbf{R}}^*$ where $\underline{\mathbf{R}}^*$ is a square ($3 \times 3$) matrix with elements $\underline{r}_{ij} = r_{ij} - r_{i4}$ $(i, j = 1, \ldots, 3)$. Allowing for the most general specification of the autocorrelation parameters only requires that each column of the $\underline{\mathbf{R}}^*$ matrix sums to zero.

The models were estimated both with and without the adding-up ($\Sigma \xi_i = 1$; $\Sigma \tau_i = 0$; $\Sigma \phi_i = 0$; $\Sigma \rho_{1i} = 0$; $\Sigma \rho_{2i} = 0$; $\Sigma \omega_{ij} = 0$; $\Sigma \theta_{1i} = 0$; $\Sigma \theta_{2i} = 0$; $\Sigma \gamma_{ij} = 0$), homogeneity ($\Sigma \beta_i = 0$), and symmetry ($\gamma_{ij} = \gamma_{ji}$) conditions imposed on the system. Using the joint test procedure of Gallant [17], we found no significant difference between the restricted and unrestricted models ($\chi^2_{(0.05, 16)} = 24.24$). Reported results are based on the restricted (theoretically consistent) models.

There is some question on whether to restrict $\alpha_0$; Deaton and Muelbauer suggest that $\alpha_0$ be restricted to some small positive number because this parameter can be interpreted as the natural log of subsistence monthly outlay on goods in the system when prices are unity (i.e., $\log e(\cdot) = \alpha_0$ when $U = 0$ and all $P_{jt} = 1$). In addition, many published articles using AIDS models do not report whether they impose a restriction on $\alpha_0$, nor do they commonly report an estimate for $\alpha_0$. In response, we estimated the model without restricting $\alpha_0$; the unrestricted $\alpha_0$ was estimated as equal to $-4.6$, significant at the 5% level. We also estimated the model by restricting $\alpha_0$ to equal zero. A Chow test indicates that the vector of parameters across the restricted and unrestricted models are not significantly different ($\chi^2_{(0.05, 1)} = 0.75$). However, similarity in parameter vectors does not necessarily imply similarity in welfare estimates.[14] Given the above we report both sets of estimation results.

Identification of structural shifts in a time series due to a change in information is often problematic. Many authors (e.g., [29, 30]) simply assume that changes in parameter vectors are due to a change in information availability. However, estimated parameters may be spuriously correlated with nonlinear trends in the data series. We use a "switching regressions" approach [32] to test whether our hypothesized label variable correctly identifies the timing of the structural break in the data (announcement of the dolphin-safe tuna-labeling program in April 1990). In this approach, the demand system is estimated repeatedly with different possible structural breakpoints. The estimation providing the largest likelihood value is then compared with a model estimated with no breakpoint (i.e., a demand system estimated with no label variable). The likelihood values indicate that our hypothesized breakpoint does in fact provide the best fit of the data (Table I). We also find that this model is significantly different than a demand system estimated without a label variable.[15]

[14] We thank an anonymous reviewer for this insight.

[15] A CUSUM [24] test was also performed on the tuna equation; the analysis confirmed a structural change in the data beginning in the 25th time period (the month during which the dolphin-safe labeling policy was announced). Results of this analysis are available from the first author.

TABLE I
Selected Likelihood Values Testing the Timing of the Label Variable[a]

| Time period | Likelihood value |
|---|---|
| 20 | −49.11 |
| 23 | −47.94 |
| 24 | −46.74 |
| 25 | $-45.88^{A}$ |
| 26 | $-45.98^{A}$ |
| 27 | $-47.06^{B}$ |
| 30 | $-47.39^{B}$ |
| No label | $-47.21^{B}$ |

[a] Likelihood values sharing a superscript are not significantly different from each other.

The AIDS model provides estimated share equations that can be used to calculate the market effects of the labeling program and to provide estimates of the relevant parameters of the expenditure functions. The expenditure functions thus derived can be used to calculate the CV measure for a representative consumer.[16,17] By substituting the parameters of the demand system into expression (5) we obtain an estimate for the value of dolphin-safe labeling for a representative canned tuna user:

$$CV = X\left[\exp\left[\sum_i \{\{\phi_i L_t\}^* \log P_{it}\}\right] - 1\right]. \tag{13}$$

This CV is the average amount of money households would need to be compensated per month if the labeling program had not existed. Given that prices and the labeling effect (movement along the logistic information diffusion curve) are not stationary through time, CV will also change through time as prices change and the information about the label is processed by more consumers. This measure of CV is not equivalent to a hypothetical valuation approach that asked the question, "How much would you pay to prevent all dolphin mortality in the ETP from commercial fishing operations?" The dolphin-safe label does not ensure consumers that no dolphins are being killed in the ETP as a result of fishing operations; it ensures the consumer that no dolphins were killed as a result of fishing operations corresponding to a purchase of canned tuna.

A confidence interval (CI) around the mean CV estimate is constructed using a Taylor-series expansion [19]. Specifically, CI = CV $\pm\, t_{(1-\alpha)/2}\sqrt{\mathbf{ZCZ}'}$, where $\mathbf{Z}$ de-

[16] To confirm that our underlying utility function was well behaved we tested the concavity of the expenditure function using the procedure outlined in [11]. Three of the four eigenvalues were consistent with negative semidefiniteness (−0.1163, −0.0737, −0.0037). Although the fourth eigenvalue was positive it was small (0.0007).

[17] LaFrance and Hanemann [33] show that estimation of the welfare effects due to a change in a nonprice parameter is only valid if one assumes that the constant of integration is not affected by changes in the nonprice parameter. Unfortunately, this assumption has no behavioral consequences and is thus untestable. As a result, "it is generally impossible to measure unequivocally welfare changes from non-market effects using incomplete systems of market demand functions" (p. 272).

notes a row vector composed of the partial derivatives of the CV expression with respect to the estimated parameters (here, $\partial \mathrm{CV}/\partial \phi_i$) and **C** denotes the covariance matrix of the parameters.

## IV. DATA

Market-related information (market share, retail-sponsored advertising indices, and share prices) was obtained from SCANTRACK® scanner data supplied by the A.C. Nielsen Marketing Research Company. The scanner data include monthly sales, price, and retail-support information for all scannable food items in 3000 supermarkets in the United States with at least $2 million in annual sales (estimated to cover 84% of all supermarket sales). Nielsen then projects the data to provide national estimates for all supermarkets with annual sales of over $2 million. For the analysis, package sizes and prices are converted into standardized 16-oz. equivalent units. The retail-sponsored advertising indices denote the percent of stores in the SCANTRACK® data that used a special display, coupon, or advertisement to promote the specific product during the month. This study uses a monthly data series beginning in April 1988 and ending in December 1995.

Information used to construct the media index was obtained using the DIALOG Information Retrieval Service. The newspaper and magazine databases accessed through DIALOG include the full text of all news stories and feature articles in over 60 newspapers and 400 different magazines. We searched the databases for the following keyword combinations: tuna/dolphin, dolphin-safe/tuna, dolphin-safe/label. Results of the searches were scanned to eliminate any articles that were deemed inappropriate. The index was constructed as a sum of all articles discussing the tuna–dolphin issues during the relevant time period. Articles were not coded based upon the articles content nor weighted by the prominence of each article within the newspaper/magazine because previous research indicates that these "corrections" do not add additional information. Essentially, the number of negative and positive articles tends to be highly correlated [46] and article prominence is correlated with reporting frequency [53].

## V. RESULTS AND DISCUSSION

The significant, negative coefficient on the time-trend variable in the tuna and other seafood equations indicates that, *ceterus paribus*, there exists a downward trend for canned tuna and other seafood market share (Tables II and III). Conversely, the significant, positive coefficient on the time-trend variable in the luncheon meat equation indicates that there exists an upward trend for this product. Note that both these trends exist even though we hold constant for the information effects surrounding the tuna–dolphin controversy via the video, media, and labeling coefficients. These trend coefficients may reflect the U.S. population's changing preferences for these different products. This interpretation may also be indicated by the positive, significant coefficient on the expenditure variable in the luncheon meat equation, indicating that expenditures on luncheon meat expand relatively more rapidly as total expenditures increase. The negative time trend for canned tuna could also be a result of the changing quality of canned tuna. Due to

TABLE II
Estimated Share Equations, $\alpha_0$ Restricted to Zero[a]

| | Tuna | Luncheon meat | Seafood | Red meat |
|---|---|---|---|---|
| Intercept ($\xi$) | 0.31904* | 0.47335* | 0.11055* | 0.09706 |
| | (0.01164) | (0.0123) | (0.00541) | |
| Expenditure ($\beta$) | −0.00357 | 0.01785* | −0.00362 | −0.01066 |
| | (0.00514) | (0.0073) | (0.00414) | |
| Time trend ($\tau$) | −0.0003* | 0.00055* | −0.00024* | −0.00001 |
| | (0.00005) | (0.00007) | (0.00004) | |
| Label ($\phi$) | 0.00726** | −0.01661* | 0.00861* | 0.00074 |
| | (0.00385) | (0.00597) | (0.00325) | |
| Lent ($\theta_1$) | 0.01238* | −0.0218* | 0.00644* | 0.00298 |
| | (0.00211) | (0.00304) | (0.0017) | |
| December ($\theta_3$) | −0.00519* | 0.00294 | −0.00113 | 0.00338 |
| | (0.00226) | (0.00319) | (0.00173) | |
| Video ($\rho_2$) | −0.00712* | −0.00034 | 0.0059* | 0.00156 |
| | (0.00339) | (0.00537) | (0.00294) | |
| Media ($\rho_1$) | 0.00024 | −0.00057 | 0.00059* | −0.00026 |
| | (0.00025) | (0.00038) | (0.00021) | |
| Advertising ($\omega$) | | | | |
| *Tuna* | 0.00035* | −0.00032* | 0.00003 | −0.00006 |
| | (0.00004) | (0.00005) | (0.00002) | |
| *Luncheon meat* | −0.00032* | 0.00047* | −0.00022* | 0.00007 |
| | | (0.00008) | (0.00003) | |
| *Seafood* | 0.00003 | −0.00022* | 0.00024* | −0.00005 |
| | | | (0.00002) | |
| *Red meat* | −0.00006 | 0.00007 | −0.00005 | 0.00004 |
| Log price ($\gamma$) | | | | |
| *Tuna* | 0.1402* | −0.14471* | 0.0152* | −0.01069 |
| | (0.01421) | (0.01444) | (0.00459) | |
| *Luncheon meat* | −0.14471 | 0.17317* | −0.01982* | −0.00864 |
| | | (0.02531) | (0.00702) | |
| *Seafood* | 0.0152 | −0.01982 | 0.00139 | 0.00323 |
| | | | (0.00399) | |
| *Red meat* | −0.01069 | −0.00864 | 0.00323 | 0.01610 |
| Adj. $R$-square | 0.9443 | 0.9468 | 0.8997 | 0.7932 |

[a] Standard errors are reported in parenthesis.
* denotes significance at the 0.05 level.
** denotes significance at the 0.10 level. Note: standard errors and significance levels are not reported for restricted parameters.

the dolphin-safe criteria, fishermen began landing smaller yellowfin and skipjack tuna less suitable as a canned product than large yellowfin tuna.

The significant coefficients on the video variables indicate that the negative media activity surrounding the tuna−dolphin issue seems to have depressed sales of canned tuna (Fig. 1) and increased market share of other canned seafood. The labeling coefficient in the tuna-share equation is significant and positive, indicating that the presence of dolphin-safe labels increased tuna market share and, given the functional form of this variable, that this increase in market share increased over a period of several months. The label coefficient is negative in the luncheon meat equation. Thus the presence of dolphin-safe labels seems to have caused declines in the luncheon meat markets. Although predicted market share of tuna is declining through time, the labeling program slowed this decrease so that by

TABLE III

Estimated Share Equations, $\alpha_0$ not restricted[a, b]

| | Tuna | Luncheon meat | Seafood | Red meat |
|---|---|---|---|---|
| Intercept ($\xi$) | 0.34570* | 0.43570* | 0.10638* | 0.11222 |
| | (0.03055) | (0.03824) | (0.02029) | |
| Expenditure ($\beta$) | −0.00363 | 0.01293** | −0.00064 | −0.00865 |
| | (0.00501) | (0.00705) | (0.00377) | |
| Time trend ($\tau$) | −0.00031* | 0.00048* | −0.00022* | 0.00004 |
| | (0.00005) | (0.00007) | (0.00004) | |
| Label ($\phi$) | 0.00904* | −0.01415* | 0.00774* | −0.00263 |
| | (0.00385) | (0.00594) | (0.00322) | |
| Lent ($\theta_1$) | 0.01205* | −0.02087* | 0.00594* | 0.00289 |
| | (0.00209) | (0.00306) | (0.00171) | |
| December ($\theta_3$) | −0.00454* | 0.00460 | −0.00195 | 0.00189 |
| | (0.00223) | (0.00310) | (0.00160) | |
| Video ($\rho_2$) | −0.00712* | 0.00193 | 0.00534** | −0.00015 |
| | (0.00344) | (0.00530) | (0.00290) | |
| Media ($\rho_1$) | 0.00025 | −0.00066** | 0.00065* | −0.00024 |
| | (0.00024) | (0.00037) | (0.00021) | |
| Advertising ($\omega$) | | | | |
| *Tuna* | 0.00034* | −0.00032* | 0.00003 | −0.00005 |
| | (0.00004) | (0.00005) | (0.00003) | |
| *Luncheon meat* | −0.00032* | 0.00050* | −0.00023* | 0.00005 |
| | | (0.00008) | (0.00004) | |
| *Seafood* | 0.00003 | −0.00023* | 0.00023* | −0.00003 |
| | | | (0.00002) | |
| *Red meat* | −0.00005 | 0.00005 | −0.00003 | 0.00003 |
| Log price ($\gamma$) | | | | |
| *Tuna* | 0.14146* | −0.12529* | 0.01417* | −0.03034 |
| | | (0.01396) | (0.01462) | (0.00471) |
| *Luncheon meat* | −0.12529* | 0.16854* | −0.02804* | −0.01521 |
| | | (0.02407) | (0.00722) | |
| *Seafood* | 0.01417* | −0.02804* | 0.00421 | |
| | | | (0.00400) | |
| *Red meat* | −0.03034 | −0.01521 | 0.00967 | 0.03588 |
| Adj. $R$-square | 0.94340 | 0.94880 | 0.90320 | 0.81880 |

[a] Standard errors are reported in parenthesis.

[b] The estimated $\alpha_0 = -4.6885$ with a standard error of 1.8702, which is significant at the 5% level.

* denotes significance at the 0.05 level.

** denotes significance at the 0.10 level. Note: standard errors and significance levels are not reported for restricted parameters.

December 1995 tuna market share with the labeling program is roughly 1% higher than the estimated market share in absence of the label (Fig. 1).

The results demonstrate that the impact of a labeling program may not be felt immediately as the best fitting functional form for the label variable takes on an S-shape similar to previous models of information diffusion. We suggest two possible reasons for this temporal effect. The first is the presence of a pure information diffusion process. A few interested or knowledgeable consumers immediately notice the label change while others only notice and react to the label after several in-store exposures or after discussions with friends and neighbors who

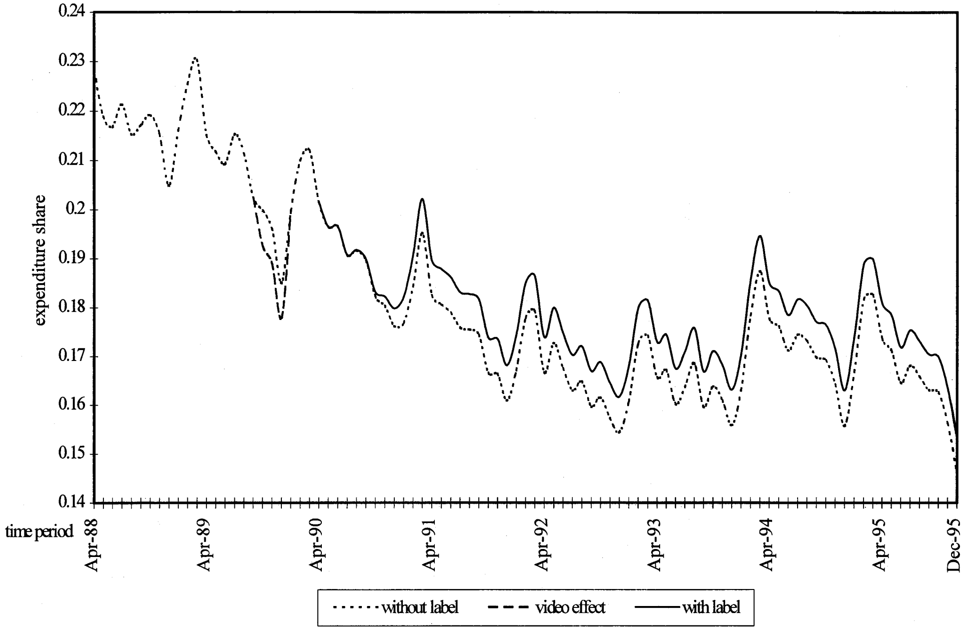


**FIG. 1.** Market effects of information: Expenditure share of canned tuna.

have already noticed and reacted to the label. The second effect may derive from a verification effect. That is, some consumers may have noticed the new labels but did not believe the label information. As information that verifies the label claim is presented to these consumers (from media, lawmakers, etc.), they may have increased their canned tuna consumption to reflect their level of trust. Diffusion of awareness about the dolphin-safe label and increases in perceived believability may explain the temporal increase in tuna's market share.

The coefficients on the "own" advertising variables are positive in all equations and significant in the tuna, luncheon meat, and other seafood equations, indicating that increases in product advertising seem to increase market share. Conversely, luncheon meat advertising seems to decrease tuna and other seafood market share. Similarly, tuna and other seafood advertising decreases luncheon meat market share. The coefficients on the "religious–seasonal" variables ($\theta_1$ and $\theta_2$) indicate that the market share of tuna and seafood increases during Lent while the market share of luncheon meats decreases. In addition, during the winter holiday season the market share of tuna decreases.

All of the own-price elasticities (both Marshallian and Hicksian) are negative, indicating downward sloping demand (Table IV).[18] The positive signs on most of the Hicksian cross-price elasticities indicate that most of the goods are substitutes to one another. The price elasticities all fall between the ranges of $-1$ and 1. Though this is partly a result of the restrictions placed on the estimated parameters, it does provide a realistic range of price responses for food items. The

[18] The elasticity formulas for the AIDS model are reported in numerous places [7, 22]. The introduction of labeling, advertising, and other variables in our AIDS model does not significantly change these formulas so we will not report them here.

TABLE IV
Estimated Elasticities for Canned Meat Products

| | Tuna | Luncheon meat | Seafood | Red meat |
|---|---|---|---|---|
| | $\alpha_0$ restricted to zero | | | |
| *Marshallian* | | | | |
| Tuna | −0.2664 | −0.7421 | 0.0806 | −0.0535 |
| Luncheon meat | −0.2340 | −0.7438 | −0.0334 | −0.0169 |
| Seafood | 0.2353 | −0.2604 | −0.9753 | 0.0538 |
| Red meat | −0.0803 | −0.0215 | 0.0384 | −0.8358 |
| *Hicksian* | | | | |
| Tuna | −0.0778 | −0.1195 | 0.1471 | 0.0503 |
| Luncheon meat | −0.0364 | −0.0916 | 0.0363 | 0.0918 |
| Seafood | 0.4171 | 0.3401 | −0.9111 | 0.1539 |
| Red meat | 0.0925 | 0.5489 | 0.0993 | −0.7407 |
| *Expenditure* | 0.9814 | 1.0281 | 0.9465 | 0.8992 |
| | $\alpha_0$ not restricted | | | |
| *Marshallian* | | | | |
| Tuna | −0.2595 | −0.6419 | 0.0752 | −0.1550 |
| Luncheon meat | −0.2021 | −0.7453 | −0.0458 | −0.0272 |
| Seafood | 0.2111 | −0.4085 | −0.9372 | 0.1440 |
| Red meat | −0.2686 | −0.0996 | 0.0978 | −0.6477 |
| *Hicksian* | | | | |
| Tuna | −0.0710 | −0.1956 | 0.1418 | 0.0512 |
| Luncheon meat | −0.0060 | −0.0980 | 0.0234 | 0.0807 |
| Seafood | 0.4014 | 0.2199 | −0.8700 | 0.2487 |
| Red meat | −0.0922 | 0.4828 | 0.1601 | −0.5506 |
| *Expenditure* | 0.9811 | 1.0204 | 0.9906 | 0.9181 |

magnitudes of these results are similar to other meat demand studies [16, 27]. Conforming to expectations, the positive signs of the expenditure elasticities indicate that the share of expenditures spent on an item increases as expenditures on proteins increase.

The confidence intervals indicate that the mean monthly CV estimates for a representative household are different based on whether $\alpha_0$ is restricted (Table V). In general, the CV estimates from the unrestricted equation are approximately three times greater than the CV estimates from the restricted equation. In addition, the confidence intervals indicate that the mean monthly CV estimates from the restricted equation are not consistently significantly different from zero until 10 months after the announced dolphin-safe labeling policy, whereas the CV estimates from the unrestricted equation are significantly different from zero immediately after the announcement. Similar to the market results, to accurately measure all of the benefits from the labeling program one must look beyond instantaneous effects. Notably, once the label effect is fully realized, the magnitude of the CV estimates remains relatively stable across the remaining time period. Variation in reported CV after 1991 is due solely to changes in relative prices and incomes; CV is relatively lower (higher) during months in which the price of tuna was relatively lower (higher). The U.S. aggregate annual CV from the restricted equation is approximately \$6 million (monthly per household CV $*$ 12 months/year $*$ 92.62 million households), whereas the comparable estimate from the unrestricted equation is about \$15 million (Table VI).

TABLE V

Estimated Representative Household Compensating Variations for Selected Months[a]

| Time period | $\alpha_0$ restricted to zero | | | $\alpha_0$ not restricted | | |
|---|---|---|---|---|---|---|
| | Lower 95% confidence interval | Mean | Upper 95% confidence interval | Lower 95% confidence interval | Mean | Upper 95% confidence interval |
| Pre-April 1990 | n/a | n/a | n/a | n/a | n/a | n/a |
| May | −$0.000041 | −$0.000040 | −$0.000039 | $0.000069 | $0.000070 | $0.000071 |
| June | −$0.000077 | −$0.000072 | −$0.000067 | $0.000015 | $0.000019 | $0.000024 |
| July | −$0.000021 | −$0.000010 | $0.000001 | $0.000035 | $0.000046 | $0.000057 |
| August | −$0.000031 | −$0.000002 | $0.000027 | $0.000128 | $0.000156 | $0.000184 |
| September | −$0.000065 | $0.000029 | $0.000123 | $0.000363 | $0.000455 | $0.000547 |
| October | $0.000165 | $0.000344 | $0.000523 | $0.001247 | $0.001424 | $0.001601 |
| November | $0.000368 | $0.000748 | $0.001128 | $0.002726 | $0.003096 | $0.003466 |
| December | −$0.000615 | $0.000205 | $0.001025 | $0.003945 | $0.004755 | $0.005565 |
| January 1991 | −$0.000559 | $0.000381 | $0.001321 | $0.006290 | $0.007210 | $0.008130 |
| February | $0.003279 | $0.004469 | $0.005659 | $0.011168 | $0.012348 | $0.013528 |
| March | $0.005059 | $0.006709 | $0.008359 | $0.013594 | $0.015224 | $0.016854 |
| April | $0.002867 | $0.004087 | $0.005307 | $0.011327 | $0.012537 | $0.013747 |
| May | $0.002426 | $0.003676 | $0.004926 | $0.012032 | $0.013262 | $0.014492 |
| June | $0.000717 | $0.002397 | $0.004077 | $0.009387 | $0.011017 | $0.012647 |
| July | $0.003184 | $0.004604 | $0.006024 | $0.010448 | $0.011848 | $0.013248 |
| August | $0.004621 | $0.006061 | $0.007501 | $0.013061 | $0.014481 | $0.015901 |
| September | $0.003108 | $0.004868 | $0.006628 | $0.011772 | $0.013502 | $0.015232 |
| September 1992 | $0.006901 | $0.008641 | $0.010381 | $0.015047 | $0.016767 | $0.018487 |
| September 1993 | $0.002485 | $0.004045 | $0.005605 | $0.010514 | $0.012054 | $0.013594 |
| September 1994 | $0.003200 | $0.004640 | $0.006080 | $0.010555 | $0.011975 | $0.013395 |
| September 1995 | $0.003946 | $0.005416 | $0.006886 | $0.011624 | $0.013074 | $0.014524 |

[a] All values are in 1990 dollars.

## VI. CONCLUSIONS AND LIMITATIONS

The results support our hypothesis that the dolphin–tuna controversy and the subsequent implementation of dolphin-safe labeling affected consumer behavior. Further, the paper provides market-based evidence that consumers can respond to eco-labels. The statistical significance of the label coefficient in the tuna share equation indicates the dolphin-safe label did increase the market share of canned tuna and that this increase continued over time. When measuring market or welfare effects of labeling programs it is important to recognize that consumers may not respond instantaneously to these programs. After the introduction of the label, shares of other products decreased as people substituted back to tuna, providing an interesting look at how people substitute between products based on moral or ideological grounds. Finally, the welfare analysis may provide a partial measure of society's willingness to pay to avoid personally contributing to dolphin mortality as a result of tuna fishing.

In addition to changes in consumer behavior the presence of eco-labeling may alter manufacturer behavior. That is, if a significant portion of the consumer population demands environmentally friendly products, the presence of an eco-labeling program may provide firms an incentive to differentiate and market their

TABLE VI
Estimated U.S. Aggregate Compensating Variations for Selected Months[a]

| Time period | $\alpha_0$ restricted to zero | $\alpha_0$ not restricted |
|---|---|---|
| Pre-April 1990 | n/a | n/a |
| May | *−$44,313*[b] | $77,630 |
| June | *−$79,930* | $21,668 |
| July | *−$11,602* | $50,586 |
| August | *−$2,655* | $173,358 |
| September | *$32,699* | $505,764 |
| October | $382,005 | $1,582,594 |
| November | $830,903 | $3,441,224 |
| December | *$228,347* | $5,284,611 |
| January 1991 | *$423,190* | $8,013,818 |
| February | $4,967,483 | $13,723,742 |
| March | $7,456,189 | $16,920,634 |
| April | $4,541,998 | $13,933,747 |
| May | $4,085,882 | $14,740,139 |
| June | $2,664,550 | $12,244,243 |
| July | $5,116,661 | $13,168,659 |
| August | $6,736,335 | $16,094,725 |
| September 1991 | $5,410,688 | $15,007,204 |
| September 1992 | $9,603,627 | $18,635,730 |
| September 1993 | $4,495,675 | $13,397,597 |
| September 1994 | $5,156,843 | $13,309,844 |
| September 1995 | $6,019,270 | $14,531,233 |

[a] All values are in 1990 dollars.
[b] Italicized aggregate estimates are based on household estimates not significantly different from zero.

products along an environmental characteristic(s). An increase in supply of these environmentally friendly products may increase consumer purchases simply through greater availability without changes in individual awareness.

Evidence that providing information to consumers through labeling can alter behavior is likely to be welcomed by policymakers because this sort of policy tool may be easier to implement and enforce than explicit production site regulations. Furthermore, recent trade agreements restrict the use of economic sanctions as a way of influencing trading partners. However, labeling allows market behavior to influence trading partners while complying with trade agreements.

This study is limited in that it identifies the effects of the labeling program only through changes in aggregate consumption before and after the introduction of labeling due to simultaneous implementation by the major tuna industry suppliers; no observable cross-sectional variation in labeling occurred in our data. Further research involving cross-sectional variation in eco-labeling from other markets will broaden our understanding of the efficacy of such programs in terms of altering consumption.

Another critique of this research involves identifying the true marginal effect of the on-package labeling. That is, would consumption patterns have changed in a different fashion if all the same events took place (media stories, release of the video, Congressional action, supplier announcements concerning changes in production practices) except that no label was ever placed upon a package? What role does the label play in educating the public about the change in supplier policy? Answers to these questions would help to identify the effect of various informational policies and determine their substitutability and complementarity. As in the study of food labels, a better understanding of such possible effects and improved calibration of models may require both experimental and quasi-experimental approaches.[19]

The 105th Congress has redefined the meaning of dolphin safe. Under The International Dolphin Conservation Program Act [43], a tuna product could be labeled dolphin safe if no dolphins were killed while capturing tuna. This would allow fishermen to chase and encircle dolphin schools and still meet the dolphin-safe requirement so long as no dolphins are killed. Given the paucity of quantitative research on the impact of the original dolphin-safe labels, it is not clear how a new definition would impact consumer behavior. Our results indicate it might take consumers some time to fully adjust to the new definition.

## REFERENCES

1. I. Ajzen, T. C. Brown, and L. H. Rosenthal, Information bias in contingent valuation: Effects of personal relevance, quality of information, and motivational orientation, *J. Environ. Econom. Management* **30**, 43–57 (1996).
2. W. Bailey and M. A. Eastlick, Study shows many claiming to be green don't buy green, *Northwest Arkansas Times*, Nov. 12, 1993.
3. J. C. Bergstron, J. R. Stoll, and A. Randall, The impact of information on environmental commodity valuation decisions, *Amer. J. Agric. Econom.* **72**, No. 3, 614–621 (1990).
4. E. R. Berndt and N. E. Savin, Estimation and hypothesis testing in singular equation systems with autoregressive disturbances, *Econometrica* **43**, 937–957 (1975).
5. N. E. Bockstael and I. E. Strand, "Economic Sanctions and Environmental Preferences: Protecting Dolphins and Tuna Markets," Mimeo, Dept. of Agricultural and Resource Econ., University of Maryland (1995).
6. Bonneville Power Administration, "Report on Market Research and Program Recommendations: Bonneville Power Administration Regionwide Promotion of Energy-Efficient Appliances," B. G. William Lesh, Inc. (1985).
7. A. Buse, Evaluating the linearized almost ideal demand system, *Amer. J. Agr. Econom.* **76**, 781–793 (1994).
8. T. A. Cameron and J. Englin, Respondent experience and contingent valuation of environmental goods, *J. Environ. Econom. Management* **33**, 296–313 (1997).
9. O. Capps, Jr. and J. D. Schmitz, A recognition of health and nutrition factors in food demand analysis, *Western J. Agr. Econom.* **16**, No. 1, 21–35 (1991).
10. R. M. T. Castagnini, T. L. Cox, and C. F. Perali, On the choice of functional forms in demand analysis: An application to beverage consumption in Italy 1960–1990, *presented at* the Annual Meeting of the American Agricultural Economics Association, 1996.
11. J. A. Chalfont and K. J. White, "Estimation and Testing in Demand Systems with Concavity Constraints," Department of Agricultural and Resource Economics Working Paper 454, University of California (1987).
12. S. W. Chang, GATTing a green trade barrier: Eco-labelling and the WTO agreement on technical barriers to trade, *J. World Trade* **31**, No. 1, 137–159 (1997).
13. D. Chase and T. K. Smith, Consumers keen on green but marketers don't deliver, *Advertising Age* June 29, 1992.

[19] For example, see Teisl and Levy [47] regarding a market-based experimental approach to determining the effects of nutrition labels.

14. R. G. Cummings, D. S. Brookshire, and W. D. Schulze, "Valuing Environmental Goods: An Assessment of the Contingent Valuation Method," Rowan and Allenheld, Totowa, NJ (1986).
15. A. S. Deaton and J. Muelbauer, An almost ideal demand system, *Amer. Econom. Rev.* **70**, 312–326 (1980).
16. J. Dyck, "Demand for Meats in Japan: A Review and Update of Elasticity Estimates," AGES88-525, U.S. Department of Agriculture, Economic Research Service, Agriculture and Trade Analysis Division.
17. A. R. Gallant, "Nonlinear Statistical Models," Wiley, New York (1987).
18. X. M. Gao, E. J. Wailes, and G. L. Cramer, A synthetic demand system: An application to U.S. consumer demand for rice and selected rice substitutes, *Rev. Agr. Econom.* **16**, 27–38 (1994).
19. W. H. Greene, "Econometric Analysis," 4th ed., Prentice Hall, Upper Saddle River, NJ (2000).
20. R. D. Green, Z. A. Hassan, and S. R. Johnson, Selection of nonnested demand models, *Canad. J. Agr. Econom.* **43**, 485–499 (1995).
21. R. D. Green and J. Alston, Elasticities in AIDS models: A clarification and extension, *Amer. J. Agr. Econom.* **73**, 874–875 (1991).
22. E. F. Greenberg, ISO 14000 to change business environment, *Packaging Dig.* **33**, No. 4, 20–22 (1996).
23. R. Gutfield, Shades of green: Eight of 10 Americans are environmentalists, or at least say so, *Wall Street J.*, August 2, 1991.
24. A. K. Han and D. Park, Testing for structural change in panel data: Application to a study of foreign trade in manufacturing goods, *Rev. Econ. Statist.* 135–142 (1989).
25. R. V. Hartwell and L. Bergkamp, Eco-labeling in Europe: New market-related environmental risks? *BNA Internat. Environ. Daily*, October 20, 1992.
26. S. Hashizume, "Environmental Labeling in Japan: The Eco-Mark," Japan Environ. Assoc. (1992).
27. J. Hayes, T. Wahl, and G. Williams, Testing restrictions on a model of Japanese meat demand, *Amer. J. Agr. Econom.* **72**, 556–566 (1990).
28. D. Horsky, A diffusion model incorporating product benefits, price, income and information, *Market. Sci.* **9**, No. 4, 342–365 (1990).
29. P. M. Ippolito and A. D. Mathios, Information, advertising and health choices: A study of the cereal market, *RAND J. Econom.* **21**, 459–480 (1990).
30. P. M. Ippolito and A. D. Mathios, "Information and Advertising Policy: A Study of Fat and Cholesterol Consumption in the United States, 1977–1990," Bureau of Economics Staff Report, Federal Trade Commission (1996).
31. J. Joseph, The tuna–dolphin controversy in the Eastern Pacific Ocean: Biological, economic, and political impacts, *Ocean Develop. Internat. Law* **25**, 1 (1994).
32. G. G. Judge, R. C. Hill, W. E. Griffiths, H. Lutkepohl, and T. C. Lee, "Introduction to the Theory and Practice of Econometrics," Wiley, New York (1988).
33. J. T. LaFrance and M. Hanemann, The dual structure of incomplete demand systems, *Amer. J. Agr. Econom.* **71**, 262–274 (1989).
34. J. T. LaFrance, "Weak Separability and Two-Stage Budgeting: Estimation and Welfare Measurement," Agricultural Economics and Economics Department Staff Paper 89-3, Montana State University (1989).
35. J. T. LaFrance, When is expenditure "exogenous" in separable demand models? *Western J. Agr. Econom.* **16**, 49–62 (1991).
36. J. T. LaFrance, "Incomplete Demand Systems, Weak Separability and Weak Complimentarity in Applied Welfare Analysis: Expanded Version," Department of Agricultural Economics Working Paper 77, University of Arizona (1992).
37. J. T. LaFrance, Weak separability in applied welfare analysis, *Amer. J. Agr. Econom.* **75**, 770–775 (1993).
38. A. Levy, O. Mathews, M. Stephenson, J. Tenney, and R. Schucker, The impact of a nutrition information program on food purchases, *J. Public Policy Market.* **4**, 1–13 (1985).
39. A. Lewbel, Nesting the aids and translog demand systems, *Internat. Econom. Rev.* **30**, 349–356 (1989).
40. L. Loro, Green marketing comes to computers, *Advertising Age*, September 29, 1993.
41. National Research Council, "Dolphins and the Tuna Industry," National Academy Press (1992).
42. N. E. Piggott, J. A. Chalfont, J. M. Alston, and G. R. Griffith, Demand response to advertising in the Australian meat industry, *Amer. J. Agr. Econom.* **78**, No. 2, 268–279 (1996).

43. PL 42, 105th Congress, The International Dolphin Conservation Program Act.
44. SAMI/Burke, "The SAMI/Burke Good Housekeeping Seal Study," Good Housekeeping Institute (1988).
45. P. Shabecoff, Three companies to stop selling tuna caught with dolphins, *New York Times*, April 13, 1990.
46. M. E. Smith, E. O. van Ravenswaay, and S. R. Thompson, Sales loss determination in food contamination incidents: an application to milk bans in Hawaii, *Amer. J. Agr. Econom.* **70**, 513–520 (1988).
47. M. F. Teisl and A. S. Levy, Does Nutrition Labeling lead to Healthier Eating? *J. Food Distribution Res.* **28**, No. 3, 18–27 (1997).
48. U.S. Dept. of Agriculture, "Continuing Survey of Food Intakes by Individuals" (1991).
49. U.S. Environmental Protection Agency, "Environmental Labeling in the United States: Background Research, Issues and Recommendations," Applied Decision Analysis (1989).
50. U.S. Environmental Protection Agency, "Assessing the Environmental Consumer Market" (1991).
51. U.S. Environmental Protection Agency, "Status Report on the Use of Environmental Labels Worldwide" (1993).
52. U.S. Environmental Protection Agency, "Determinants of Effectiveness for Environmental Certification and Labeling Programs" (1994).
53. E. O. van Ravenswaay and J. P. Hoehn, The impact of health risk and food demand: A case study of Alar and apples, *in* "Economics of Food Safety" (J. Caswell, Ed.), Elsevier Science, New York (1991).
54. P. Wallstrom and C. R. Wessells, "Analysis of Consumer Demand for Canned Tuna: Impact of Dolphin-Safe Controversy," *presented at* the VII Conference of the International Institute of Fisheries Economics and Trade, July 1994.
55. S. Yamaki, "Critical Analysis of the Vermont Household Hazardous Product Shelf-Labeling Program on Consumer Awareness: A Survey Evaluation" (1992).