Valuing the Effects of Water Quality on Recreational Resources (Richard C. Bishop, University of Wisconsin-Madison, presiding)

FISH CONSUMPTION ADVISORIES: INCORPORATING ANGLER-SPECIFIC KNOWLEDGE, HABITS, AND CATCH RATES IN A SITE CHOICE MODEL

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Fish consumption advisories are often used to warn recreational anglers that toxic contaminants in fish can result in acute or chronic illness if eaten. Advisories are an important management tool because adverse health consequences can be averted while avoiding potentially large clean-up costs. Holland and Wessells recently found that food safety was a key product attribute for fresh seafood, so it is not unreasonable for policy makers to assume that safety is an important attribute for sport anglers catching freshwater fish. However, reliance on advisories as a management strategy assumes that anglers know about advisories and follow recommended practices concerning consumption. Unfortunately, little research investigating the assumption that anglers respond to advisories or the costs associated with angler response has been reported.

Economists have only recently addressed the issue of fish consumption advisories in the published literature. MacDonald and Boyle found that 63% of anglers in Maine knew about the statewide mercury contamination advisory on lakes and ponds, but fewer than one-quarter of knowledgeable anglers engaged in averting behavior (e.g., consume fewer fish or none at all, or fish uncontaminated waters). Among Maine anglers responding to advisories, the seasonal loss in consumer surplus was $151. Jakus et al. estimated a repeated discrete choice travel cost demand model capturing the site-substitution response of anglers. Seasonal welfare losses associated with a substitution response were found to be about $47 for anglers in east Tennessee, where fish in six of fourteen major reservoirs were under consumption advisories because of PCB contamination.[1]

The Jakus et al. study represents the only published indirect valuation approach to modeling the impacts of consumption advisories, but the researchers were forced to assume that all anglers were aware of advisories. MacDonald and Boyle, along with a number of other authors (e.g., May and Burger; Diana, Bisogni, and Gall) have cast doubt on this assumption by showing that not all anglers know about advisories. Further, advisories may have different impacts depending on the angler's goal: those fishing primarily to eat their catch may respond to an advisory differently from a catch and release (C&R) angler who will not eat the catch. It is possible that reduced harvest by consumption anglers may actually increase site quality for C&R anglers as the stock of fish increases. In this way, the welfare changes associated with fish consumption advisories may be positive or negative, depending on angler type.

This study used a multinomial logit (MNL)

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[1] Two recent studies have examined toxics in water. Montgomery and Needelman found that per capita losses resulting from contamination of New York state lakes and ponds were approximately $63 per year. Parsons and Hauber found that Maine anglers would benefit about $289 per year if all toxic rivers within a four hour drive were cleaned up.

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site choice model to examine the impacts of sportfishing consumption advisories in eastern Tennessee. The model includes information about the type of angler and whether or not the angler knew about fish consumption advisories. Further, catch rates are endogenously determined for each site, avoiding biases associated with ad hoc assumptions regarding the catch rate at sites not actually visited by a particular angler.

Data

The University of Tennessee Human Dimensions Lab collected data in spring and fall 1997 by a random digit dial telephone survey of households from the general Tennessee population. After they were adjusted for ineligible numbers and numbers at which no contact was made with a household representative, the response rates were 43.5% (spring) and 47.1% (fall). Participants were asked about fishing and hunting activities over the six month period immediately prior to the interview. If a respondent indicated he or she had fished in reservoirs, detailed questions were asked about which reservoirs were fished, how often, and the average catch rate (an aggregate of all species) at each reservoir. Respondents were also asked if they fished primarily for C&R or to eat most of their catch, and if they knew of fish consumption advisories on Tennessee reservoirs. A sample of 222 reservoir anglers from a thirty-five-county region of east Tennessee provided complete data. About 60.8% of the respondents said they fished primarily for C&R, whereas 22.5% fished primarily for consumption of their catch. The remaining 16.7% said they engaged in both C&R and consumption. Just under 65% said they were aware of fish consumption advisories on Tennessee reservoirs.

Twelve major reservoirs within the thirty-five-county region and two outside the region formed a choice set accounting for over 98% of all reservoir fishing trips. The maximum driving time between any origin within the region and any reservoir was less than four hours.[2] Six of the fourteen reservoirs were under some form of fish consumption advisory because of PCB contamination (Boone, Ft. Loudon, Melton Hill, Nickajack, Tellico, and Watts Bar). Advisories ranged from limited consumption of selected species to an advisory indicating zero consumption of selected species.

Methods

The basic form of the MNL site choice model is reasonably well known and can be found in any number of publications (e.g., Morey; Bockstael, McConnell, and Strand). The model assumes that on each choice occasion the angler will visit the site yielding the greatest utility. For any two sites j and k, angler i will choose site j if the utility at site j is greater than the utility at any other site k, i.e., if

$$(1) \qquad V_i^j(p_i^j, q_i^j) + \epsilon^j > V_i^k(p_i^k, q_i^k) + \epsilon^k \quad \text{for all } j \neq k$$

where $V(\cdot)$ is the indirect utility function, p_i^j is the travel cost of person i to site j, q_i^j is the quality experienced by person i at site j, and all other arguments have been suppressed. Assuming the errors are extreme value distributed, the probability that person i visits site j can be given by, $\pi_i^j = \exp[V_i^j(p_i^j, q_i^j)]/\Sigma_k^K \exp[V_i^k, q_i^k)]$. The log likelihood function is weighted by trips made to each site k by each person i, t_i^k, and then summed over all people and sites in the sample, $\ln L = \Sigma_i^N \Sigma_k^K t_i^k \ln \pi_i^k$. Maximization of the function yields parameter estimates for the indirect utility function.

This formulation includes a key feature complicating the model: the q_i^j indicates that site quality characteristics may vary with each angler, so angler-specific quality measures are needed for each site. Although this does not pose a problem for exogenous site characteristics (e.g., the number of boat ramps), it is a problem for characteristics that may be endogenous to the angler, such as the catch rate at a site, because anglers rarely visit all sites in a choice set. Some measure of "expected" catch is needed. A common approach is to substitute the mean catch rate for the site, but Morey and Waldman demonstrated that this ad hoc solution results in an errors-in-variables problem. The catch rate and travel cost parameters are biased downward, affecting welfare measures.

This issue has been addressed empirically by Englin, Lambert, and Shaw and Morey and

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[2] Parsons and Hauber have shown that including recreational sites more than 1.6 hours away from the origin has a negligible effect on parameter estimates, although other authors provide evidence to the contrary (e.g., Peters, Adamowicz, and Boxall).

Waldman. Englin, Lambert, and Shaw linked a Poisson catch rate model to a Poisson aggregate trips model and estimated both models simultaneously. Morey and Waldman linked Poisson catch rate models for each site to a nested logit model, again estimating the models simultaneously. A key difference between the two approaches is that Morey and Waldman estimated the catch rate for each site, whereas Englin, Lambert, and Shaw estimated a single catch rate function that varied across sites only as explanatory variables varied across sites.[3]

The Morey and Waldman model uses observed catch rates for each site to measure the probability of catch rate per unit effort,

$$(2) \qquad P(C_i^k) = \frac{\exp(-C^{k*})(C^{k*})^{C_i^k}}{C_i^k!}$$

where C_i^k is the observed catch rate for person i at site k and C^{k*} is the expected catch rate for site k as estimated with a Poisson process given in equation (2). Errors associated with the trip making process are assumed to be uncorrelated with the errors from each site. This assumption is valid if fishing skill and/or practice, as they affect the catch rate, are not site specific. The likelihood function can then be augmented with a poisson catch model for each of the K sites, where the C^{k*} are passed to the site choice portion of the model at each iteration. Letting f_i^k equal one if angler i visited site k and zero otherwise, the log likelihood function with endogenous expected catch rates is given by $\ln \mathrm{L} = \Sigma_i^N \Sigma_k^K t_i^k \ln \pi_i^k + f_i^k \ln P(C_i^k)$.[4]

Empirical Results

The catch rate models given by equation (2) were estimated with only a constant as an explanatory variable, so that the parameter for each reservoir corresponds to the natural log of the per day catch rate. The effect of catch rate (*Catch*) on site choice may vary with angler practice, so *Catch* was interacted with *Boat*, a zero-one dummy variable indicating whether the angler fished mostly from a boat (1) or the bank (0). White's generalized covariance matrix provided robust standard errors.

The first fourteen parameters of each model were the Poisson parameters for each reservoir (table 1). The estimates were positive and statistically significant in all cases. Also, the *Travel Cost* parameter was negative and statistically significant in all models, as expected. The number of boat ramps at a site (*Ramps*, a measure of site accessibility) was negative in all models (contrary to expectations) but was insignificant.

The first model examined the impact of consumption advisories on site selection, regardless of angler knowledge of advisories or angler type (C&R vs. consumption). The model assumed that all anglers were aware of advisories. *Catch* was not significant at conventional levels, but the *Catch*Boat* interaction term was statistically significant. The negative sign on *Advisory* indicated that reservoirs with fish consumption advisories were less likely to be visited relative to reservoirs without advisories, all else equal. *Advisory* was not significant with a two-tailed test but a one-tailed test of the hypothesis that the coefficient was greater than or equal to zero was rejected.

Model 1 featured a potentially unpalatable assumption: all anglers were assumed to know about advisories. However, an angler who did not know of an advisory would be unlikely to respond to it. In fact, only 65% of the anglers in the sample were aware of advisories. Knowledge of advisories can be cast within the context of the "information" problem found in the contingent valuation literature (e.g., Cameron and Englin). The site quality variable q_i^j capturing the effects of a consumption advisory may be a function of whether the angler was aware of the advisory, so that $q_i^j = q(A^j, K_i)$, where A^j indicates an advisory on reservoir j and K_i indicates knowledge by person i.[5] This was modeled with an interaction of two zero-one dummy variables indicating presence of an advisory (*Advisory*) and angler knowledge (*Know*) of the advisory.

In model 2, *Advisory*Know* took the value of one if the reservoir had an advisory and the angler had knowledge of advisories. This

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[3] The key complication with the Englin, Lambert, and Shaw approach is that the errors between the catch model and the travel cost model may be correlated, especially if factors affecting catch rate also affect trip-making behavior.

[4] Reed Johnson has pointed out a potential flaw in the Morey and Waldman methodology. If the estimated choice probability for a given site does not closely correspond to the observed probability, the maximization procedure will compensate by adjusting the expected catch rate at that site. In effect, the expected catch rate can act as a site-specific dummy variable.

[5] Cameron and Englin treat information about the environmental commodity as endogenous; here, knowledge of advisories is exogenous.

Table 1. Multinomial Site Choice Models (222 Observations)

Variable	Model 1		Model 2		Model 3	
ln Catch (Boone Reservoir)	1.53*	(10.93)[a]	1.47*	(9.22)	1.49*	(8.55)
ln Catch (Cherokee R.)	1.71*	(19.09)	1.73*	(18.54)	1.74*	(19.31)
ln Catch (Chickamauga R.)	1.78*	(21.09)	1.81*	(20.81)	1.81*	(21.36)
ln Catch (Dale Hollow R.)	1.72*	(15.52)	1.76*	(15.40)	1.75*	(15.87)
ln Catch (Douglas R.)	1.73*	(19.48)	1.76*	(19.13)	1.76*	(19.35)
ln Catch (Ft. Loudon R.)	1.69*	(17.10)	1.65*	(17.51)	1.64*	(16.34)
ln Catch (Hiwassee R.)	1.52*	(10.79)	1.57*	(10.92)	1.59*	(11.52)
ln Catch (Melton Hill R.)	1.51*	(10.06)	1.46*	(9.13)	1.46*	(8.04)
ln Catch (Nickajack R.)	1.85*	(14.73)	1.83*	(14.31)	1.80*	(15.04)
ln Catch (Norris R.)	1.80*	(21.06)	1.82*	(20.41)	1.83*	(20.36)
ln Catch (South Holston R.)	1.45*	(9.49)	1.48*	(9.42)	1.51*	(8.97)
ln Catch (Tellico R.)	1.78*	(17.49)	1.76*	(17.66)	1.73*	(19.06)
ln Catch (Watauga R.)	1.42*	(8.55)	1.44*	(8.34)	1.47*	(7.98)
ln Catch (Watts Bar R.)	1.93*	(17.39)	1.90*	(18.46)	1.88*	(18.67)
Travel cost	−0.047*	(−8.65)	−0.047*	(−8.75)	−0.047*	(−8.64)
Ramps	−0.020	(−0.83)	−0.016	(−0.69)	−0.020	(−0.74)
Catch	1.022	(1.35)	0.948	(1.34)	1.112	(1.19)
Catch*Boat	0.861*	(1.75)	0.825*	(1.70)	0.867	(1.61)
Advisory	−0.722	(−1.42)				
Advisory*Know			−0.228	(−0.59)		
Advisory*Know*Consumption					−0.700*	(−1.74)
Advisory*Know*Catch&Release					0.293	(0.62)
Mean WTP (clean/remove all advisories)[b]	$7.29		$1.49		−$0.25	
95% confidence interval[c]	−$2.60–$22.75		−$3.10–$6.69		−$0.47–−$0.11	

Note: * indicates statistically significant at $\alpha = 0.10$ (two-tailed test).

[a] Number in parentheses is the ratio of a coefficient to its asymptotic standard error.

[b] WTP = willingness to pay.

[c] Calculated by the method of Krinsky and Robb.

variable had a value of zero for all anglers who were not aware of advisories. Thus, this specification more closely resembled the information set available to anglers.[6] All coefficients retained the same signs and levels of significance as in model 1, but the *Advisory*Know* variable was statistically insignificant. This result could have occured for at least two reasons: (*a*) if advisories do not result in substitution of "clean" reservoirs for "dirty" reservoirs, and so *Advisory* in model 1 captures effects other than those intended or (*b*) if the *Advisory*Know* variable masks effects that differ across types of anglers.

For example, if an advisory caused consumption anglers to reduce harvest, then as the stock of fish increased, a more attractive fishery for C&R anglers may have resulted. Thus, an advisory may have had a negative effect on site selection for consumption anglers and a positive effect for C&R anglers. This hypothesis was investigated in model 3. The dummy variable *Advisory*Know*Consumption* took the value of one for consumption anglers who were aware of advisories and zero otherwise. If consumption anglers (22.5% of the sample) engaged in site substitution, a negative sign was expected. *Advisory*Know*Catch&Release* took the value of one for C&R anglers who were aware of advisories and zero otherwise. Under the preceding hypothesis, the expected sign was positive. In model 3, the signs of these variables conformed to expectations, but only the consumption angler dummy variable is statistically significant. This indicates a site substitution response by consumption anglers relative to C&R anglers and anglers who do both types of fishing.

Welfare gains and losses (under the assumption that all six reservoirs were cleaned up such that advisories could be removed) were estimated for each model. For model 1, which assumed that all anglers were aware of advisories, the per trip welfare gain was $7.29 (confidence intervals are reported in table 1). Model 2 restricted the impact to only those anglers with knowledge of advisories, finding average gain across all anglers to be $1.49 (anglers with no knowledge had no gain or loss). In model 3, the average per trip losses to C&R anglers outweighed gains to consumption anglers, so the overall average welfare change was negative $0.25. Mean gains to consumption anglers were $2.33 per trip, whereas mean losses to C&R anglers were $1.91.

Conclusions

This study examined the impact of fish consumption advisories, controlling for anglers' knowledge of advisories, the type of angler (consumption vs. C&R), and endogeneity of catch rates. Both knowledge and angler type have been found to influence the empirical models. Anglers who knew of the advisories and who fished primarily to consume their catch were responsive to the advisories, substituting away from reservoirs with advisories and toward reservoirs without advisories. An opposite effect was expected for C&R anglers but proved to be statistically insignificant. Information about advisories also appeared to play an important role in the travel cost models, indicating a need for research similar to the ongoing research on the roles that commodity experience and information play in direct valuation methods.

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[6] An implied assumption is that the factors giving rise to an advisory (e.g., PCBs) are not perceived in any way by anglers who are unaware of the advisory.

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