Do Sportfish Consumption Advisories Affect Reservoir Anglers' Site Choice?

Paul M. Jakus, Mark Downing, Mark S. Bevelhimer, and J. Mark Fly

Increasing numbers of freshwater ecosystems have had sportfish consumption advisories posted in recent years. Advisories are sometimes issued in lieu of environmental remediation if they are considered more cost-effective than "cleaning up" the resource, but this approach assumes that anglers adjust behavior in response to the warning. Previous studies, however, suggest that compliance with advisories can be quite low. In contrast, this study measures a statistically significant response by reservoir anglers to consumption advisories. In particular, anglers are less likely to choose to visit a reservoir with an advisory than a similar reservoir without an advisory. Furthermore, the economic losses due to advisories are quantified for anglers in two regions of Tennessee.

In recent years, growing numbers of freshwater ecosystems have had sportfish consumption advisories posted, wherein an advisory communicates to anglers a warning against consuming contaminated fish. Advisories are sometimes issued in lieu of environmental remediation when they are considered more cost-effective than "cleaning up" the resource (ESD-ORNL 1996). Implicit in this approach to limiting contamination damages are the assumptions (1) that anglers heed the warning and adjust their behavior accordingly, and (2) that adequate substitute sites are available so that angler losses in consumer surplus are small. Unfortunately, the available evidence suggests that angler compliance with advisories can be quite low.[1] Most previous studies have used on-site survey methods, however, and miss an important component of angler response to consumption advisories: the ability to fish alternative sites. MacDonald and Boyle (1997) reported that 5% of those anglers aware of the advisory said that they fished different waters, but the authors did not examine anglers' site choice responses in any detail.

This paper examines angler site choices using two versions of the random utility travel cost model: a "standard" model, which examines only the site choice decision, and a repeated discrete choice model, which allows the number of days spent fishing during the season to vary. Empirical results for reservoir fishing in Middle and East Tennessee reveal that anglers are less likely to choose a contaminated reservoir over an uncontaminated reservoir, all else being equal. Anglers' losses are estimated by simulating removal of the advisories. The estimated surplus measure incorporates the effect of substitution among alternative fishing sites and changes in the number of trips an angler may take.

This study represents a contribution because the economics literature is quite thin with respect to sportfish consumption advisories. While the food safety literature is relatively large and "traditional" demand models have been estimated for consumption advisories on commercially harvested foods (e.g., Wessells, Miller, and Brooks, 1995), little has been done on recreation demand in

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[1] May and Burger (1996) found that over two-thirds of those anglers in a New York/New Jersey estuary who knew about advisories still ate their catch, while Diana, Bisogni, and Gall (1993) estimate that 70% of New York State residents fishing Lake Ontario ate at least one species of restricted fish. MacDonald and Boyle (1997) found that while 76% of residents knew of the advisory, less than one-quarter of these anglers actually adjusted their fishing behavior in response. Velicer and Knuth (1994) reported a high degree of compliance by anglers, but their sample was composed of angler group "opinion leaders" whose actions may not be representative of the general angling population.

response to consumption advisories. MacDonald and Boyle (1997) elicit recreational angler response to a "blanket" advisory covering all open water fisheries in Maine, but they use the contingent valuation method to determine economic losses. Montgomery and Needelman (1997) use a repeated discrete choice model, finding that losses due to toxic contamination of New York state lakes and ponds are about $63 per person per year.

The next section of this paper outlines different types of fish consumption advisories and how anglers can respond to advisories. The following sections outline the econometric methods used, review the data collection procedure, and report the empirical results. The paper closes with conclusions and a future research agenda.

Fish Consumption Advisories

Background

Sportfish consumption advisories have been posted for a variety of ecosystems (lakes, rivers, and coastal waters) throughout the United States to prevent human health problems that could arise from the consumption of contaminated fish. Advisories have been issued for water bodies that represent 15% of the nation's total lake acreage, 4% of the nation's river miles, all of the Great Lakes, and a large portion of the nation's coastal area (EPA 1996). The primary contaminants responsible for advisories in the United States are mercury, polychlorinated biphenyls (PCBs), chlordane, and dioxins (Cunningham et al. 1994).[2]

Advisories often vary depending on the level of contamination and the potential for human health risk, generally falling into one of four categories: (1) no consumption by the general population, (2) no consumption by a subpopulation (pregnant women, nursing mothers, and children), (3) limited consumption (guidelines for number, size, and/or frequency of meals) by the general population, and (4) limited consumption by a subpopulation. Advisories seldom include all species in a system but usually pertain to select species or size classes because not all species or sizes assimilate contaminants at the same rate. Although the actual risk of many fish contaminants is debated (Cooper 1995; Eder and Schmidt 1995), advisories are typically issued when the contaminant concentration of sampled fish exceeds some threshold value (based on FDA standards) or as the risk of adverse health outcome increases (based on EPA assessments).

Anglers wishing to consume fish have a number of possible responses to an advisory. Among them are (1) to change fish cleaning and cooking practices to reduce contaminant exposure, (2) to decrease fish consumption but maintain other fishing habits (i.e., fish the same place and species), (3) to fish the same place, but switch the species sought or consumed, (4) to leave the system with the advisory and fish a substitute, uncontaminated system, or (5) to ignore the advisory altogether, suffering the health consequences associated with eating contaminated fish.[3] These actions entail costs that are rarely considered by decision makers.

Advisories in Tennessee

The primary contaminants responsible for advisories in Tennessee are PCBs, although mercury, chlordane, and dioxin are also cited in some advisories. Of twenty-four major reservoirs in the Tennessee and Cumberland valleys (the two major water basins in East and Middle Tennessee), seven had posted consumption advisories in 1994. Consumption of freshwater fish is common among Tennessee anglers, with more than 50% of reservoir anglers consuming fish taken from reservoirs, and 15% consuming ten or more meals during the spring and summer fishing season. Anglers are warned about fish consumption advisories via the official state fishing regulations booklet and postings at popular boat launch and bank fishing locations.

Methods

Standard Site Choice Model

Random utility models (RUM) have long been used to gauge site substitution patterns. Such a model assumes that on any given trip occasion an individual will choose the site that yields the highest level of expected utility,

$$V_i^j(p_i^j, q_i^j) + \epsilon^j > V_i^k(p_i^k, q_i^k) + \epsilon^k \textit{ for all } j \neq k,$$

[2] Most of these contaminants are of human origin, but scores of advisories in Minnesota, Wisconsin, and Florida are the result of naturally occurring mercury.

[3] Behavioral changes by anglers may also result in ecological responses. Changes in angler habits (fishing at a substitute system, switching to a substitute species, or minimizing harvest) are likely to result in decreased fishing mortality for species with consumption advisories and increased effort toward (and, possibly, harvest of) other species within the same system or of any species in substitute uncontaminated systems. A decrease in harvest may be perceived as a benefit by "sport anglers"—those anglers who release most, if not all, of their catch.

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 level at site j as experienced by person i, and the ϵ terms represent the analyst's error. If site j yields greater utility than site k, then site j will be chosen. The log likelihood function for this problem can be weighted by the number of trips made to each site k, t_i^k, to reflect the fact that over a given period of time more than one site may be visited. This function is given by

$$\ln L = \sum_i^N \sum_k^K t_i^k \ln \pi_i^k,$$

where k indexes the K sites available to person i and π is

$$\pi_i^j = \frac{\exp[V_i^j(p_i^j, q_i^j)]}{\sum_k^K \exp[V_i^k(p_i^k, q_i^k)]}$$

if the errors are distributed according to an extreme value distribution. Here, π_i^j is the probability that person i chose to fish at site j, conditional on having made the decision to go fishing. Maximization of the likelihood function yields parameters $\boldsymbol{\beta}$ of $V(\cdot)$.

Repeated Discrete Choice Model

The standard site choice model yields welfare estimates for a single recreation occasion, such as a fishing trip, but does not reflect the choices made over the course of a fishing season. The repeated discrete choice (RDC) model of Morey, Rowe, and Watson (1993) operates on the assumption that each choice occasion (e.g., a day) represents a decision to fish or not to fish. If the decision is to go fishing, the second stage decision is where to fish. The site choice decision is "nested" beneath the fishing decision, while the model is "repeated" each day over the course of the season.[4] This model was chosen because the reservoir fishing decision stage allows the angler to choose an alternative activity to reservoir fishing.

The model is implemented by calculating the inclusive value (IV) from the site choice stage, where IV summarizes the net utility of fishing:

$$IV_i = \ln\left(\sum_k^K \exp[V_i^k(p_i^k, q_i^k)]\right) + 0.577.$$

The "trip decision" compares the utility of reservoir fishing against the utility of an alternative activity, choosing the action that yields the greatest utility. Where $\mathbf{Z}_i$ is the vector of arguments characterizing the decision to fish in a reservoir (with parameters $\boldsymbol{\alpha}$), the probability of person i choosing to reservoir fish on any given choice occasion d, $P_{id}(fish)$, is given by

$$P_{id}(fish) = \frac{\exp\left(\frac{1}{\mu} IV\right)}{\exp\left(\frac{1}{\mu} IV\right) + \exp(\boldsymbol{\alpha}'\mathbf{Z})},$$

with the probability of not fishing in a reservoir given by $1 - P_{id}(fish)$; subscripts have been omitted for clarity. The term $1/\mu$ measures the correlation between the fishing site alternatives coming from the site choice decision, and is bounded by zero and one. The unconditional probability that reservoir k is chosen by person i on any choice occasion d, P_{idk}, is then given by the product of the probability that the person goes reservoir fishing on occasion d and the probability that reservoir k is chosen, $P_{id}(fish) \times \pi_i^k$. To obtain estimates for $\boldsymbol{\beta}$, $\boldsymbol{\alpha}$, and μ, the likelihood function is maximized over all persons i, choice occasions d, and sites k:

$$\sum_i^N \sum_d^D \sum_k^K Y_{idk} \ln P_{idk} + (1 - Y_{idk}) \ln(1 - P_{idk}).$$

This likelihood function estimates the site choice and fishing decisions simultaneously; in doing so the parameters of the site choice decision, $\boldsymbol{\beta}$, are scaled by $1/\mu$. Y_{idk} equals one if person i fished at site k on occasion d, and zero otherwise.

Data Collection and Choice Set Definition

Primary Data

The survey instrument on which this study is based is part of a long-term monitoring project designed to examine the behavior of Tennessee anglers and hunters. While specific behavioral responses to fish consumption advisories were not elicited, the instrument does capture complete seasonal trip data for reservoir anglers. By holding constant other important factors influencing site choice de-

[4] Alternatives to the RDC model generally combine a random utility site choice model with a poisson specification for the seasonal trips demand function (Bockstael, Hanemann, and Kling 1987; Hausman, Leonard, and McFadden 1995; Feather, Hellerstein, and Thomasi 1995; Parsons and Kealy 1995). Shonkwiler and Shaw (1997) estimate a conditional demand system in place of the site choice model. All of these models differ in how indices of price, quality, and quantity are constructed and used. None of the models enjoys a widely accepted theoretical basis (nor, for that matter, does the RDC model). This remains a lively topic of research.

cisions (distance, catch rate, and accessibility), the effect of consumption advisories can be measured.

Data were collected in the fall of 1994 using a random digit dial telephone survey method. Ten thousand randomly drawn phone numbers were called, with about 29% of these deemed ineligible because they belonged to businesses or fax machines, there were hearing/language problems, or the number was disconnected. Of the remaining numbers, 2974 completed surveys were obtained, yielding a response rate of just over 37%.[5] Respondents were asked if they had been reservoir fishing in Tennessee between March 1, 1994, and August 31, 1994. If so, reservoir anglers were asked which reservoirs were visited, how often, and the average daily catch rate at each. After adjustments for trips that were clearly multipurpose (see below), a statewide pool of 368 anglers remained.[6] Anglers averaged about fifteen trips during the season.

Distances to each reservoir were calculated using ZIPFIP. Travel cost was calculated according to convention, using the individual's wage (income divided by 2000) as an estimate of the opportunity cost of time, and an average driving speed of 50 mph. The median household income for a county was used as a proxy for those anglers not reporting income. Catch rate was measured as actual catch rate reported by the angler if he or she visited the site, and the sample mean catch rate if the reservoir was not visited. The number of ramps, a measure of "site access," was determined from maps contained in the Tennessee and North Carolina gazetteers.

Fish consumption advisories were determined from the 1994 Tennessee Fishing Regulations and the 1994 issue of *Riverpulse* (Tennessee Valley Authority). *Consumption advisory* is an "indicator variable" taking a value of one if the reservoir has an advisory in place and zero if not. This approach to capturing advisory effects does not distinguish between advisories of different "extents," i.e., different species, recommended consumption levels, etc. Instead, *consumption advisory* treats the presence of an advisory as indicative of the health of the fishery for consumption purposes.[7] The alternative to this approach is to use a technical measure of consumption risk (e.g., EPA risk assessments), but this may introduce measurement error if anglers' perceptions are not highly correlated with the technical measure.

Defining the Choice Sets

RUM site choice models using an extreme value distribution for the errors are sensitive to the choice set specification; incorrect specification can result in biased parameter estimates and violation of the independence of irrelevant alternatives assumption. This is a particular concern because past research indicated that the demand for reservoir fishing is different across regions within Tennessee (Waters 1994; Bates 1994). The literature suggests many ways in which the set of relevant alternatives can be defined; we chose to examine the patterns between origin counties and destination reservoirs.[8]

The reservoirs actually visited by anglers from a given county were identified to establish the "commodity" extent of the market, and then the set of origin counties from which each reservoir draws was identified to establish the "geographic" extent of the market. The majority of visits for any reservoir were from counties located nearby, although some reservoirs appeared to draw from a considerable distance away (>200 miles). These trips were excluded on the belief that they were likely a multipurpose visit or a multiday trip. The geographic and commodity markets were examined to identify regions within which anglers lived and took most of their trips. Important substitutes outside the region were not eliminated from the choice set; a reservoir was considered an important substitute if more than one angler from the region visited it. Figure 1 shows the final origin regions and reservoir choices (one choice is in North Carolina). Consumption advisories are concentrated in Middle Tennessee (MTN) and East Tennessee

[5] Adjusted for no contacts, the response rate was 46.7%. Fewer than 1% of ineligible numbers were due to hearing or language problems.

[6] The reservoir fishing section of the survey specifically asked respondents to consider reservoir fishing in Tennessee. Respondents were free, however, to identify all reservoirs they fished because the prompt was "Were there any other reservoirs you visited March 1 through August 31, 1994?"

[7] The data did not contain sufficient variation between advisories of different types.

[8] Peters, Adamowicz, and Boxall (1995) modeled the site choice decision three ways: using the set of all sites known to the researchers, using the random draw technique, and including only those sites actually visited *or* considered by anglers. In this case, anglers were asked to define the full set of sites considered, rather than just the set visited. The different models were found to yield different parameter estimates and welfare estimates for any given change in site characteristics. Haab and Hicks (1997) have recently proposed a method in which analysts who do not have information on the complete site choice set (all those visited *and* considered) can estimate site choice probabilities that are weighted by the probability that the site is actually in the site choice set. The method works by estimating a nested model, in which the first level nest identifies all possible combinations of site choice sets, so it is feasible only if there are a small number of sites (fewer than six).

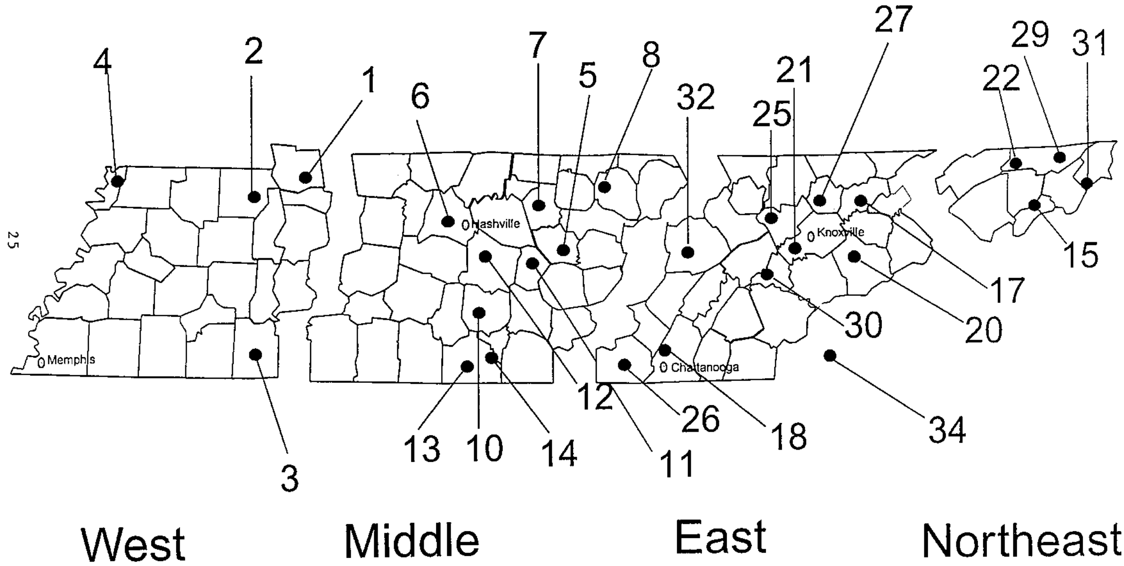

Figure 1. Reservoirs in Tennessee

(ETN), so we focus on those origins and choice sets. Choice sets are defined in table 1.

Empirical Results

The site choice model is estimated using travel cost and other site-specific quality measures, including the presence of a consumption advisory on a reservoir, as explanatory variables (table 1). This model is estimated to establish whether or not anglers adjust site selection in response to fish consumption advisories; evidence of effective advisories would be a statistically significant negative sign on *consumption advisory*. Next, the results of the season-long RDC model are presented. Consumer surplus estimates from the RDC model incorporate the effects of both site substitution and changing number of reservoir fishing trips over the length of a season.

Site Choice Model

Table 2 shows multinomial logit (MNL) site choice models. One reservoir in each of the two regions was visited by more than 25% of the sample, so site-specific intercepts for these reservoirs were estimated to capture attributes not explicitly included in the model.[9] Of the fourteen reservoirs in the choice set for the MTN region, two (14 and 26) had consumption advisories in place. Every coefficient in the site choice model has the expected sign and is statistically significant. In particular, the sign on *consumption advisory* is negative and significant, suggesting that anglers do incorporate the information contained in advisories into site choice decisions. The probabilities of visiting reservoirs 14 and 26 increase by 2.5% and 1.7%, respectively, when both advisories are removed in response to improved reservoir quality.

Of the fourteen reservoir choices in the ETN region, six (14, 21, 25, 26, 30, and 32) had fish consumption advisories. One of the reservoirs with an advisory was Watts Bar (32), the site visited by more than 25% of the ETN sample. The estimated coefficients from the MNL site choice model all have the expected sign and are statistically significant. The *travel cost* parameter is nearly identical to the parameter estimated for the MTN region, suggesting that anglers across the two regions respond to travel costs in a similar way. *Consumption advisory* is negative and significant, suggesting that, all else being equal, anglers are less likely to choose a site with an advisory than a site without an advisory. Cleaning up all reservoirs such that the consumption advisories can be removed in-

[9] Percy Priest Reservoir is immediately adjacent to metropolitan Nashville, the second largest urban area in Tennessee. Watts Bar is located approximately equidistant from Chattanooga and Knoxville, the third and fourth largest urban areas in the state. Both Percy Priest and Watts Bar are easily accessible via interstate highways and are highly commercialized relative to other reservoirs.

Table 1. Variable and Reservoir Choice Set Definitions

Travel cost	Implicit price of a trip. Roundtrip distance at $0.30 per mile, plus opportunity cost of time. Wage rate estimated at income/2000, travel at 50 mph
Catch rate	Actual catch if site is visited; mean catch rate if not visited
Ramps	Number of improved boat ramps at site
Consumption advisory	1 if advisory in place; 0 if not
Watts Bar, Percy Priest	Site-specific intercepts (both sites were visited by more than 25% of the sample)
Inclusive value	Summary of expected site utilities (from the MNL model)
Age	Age of angler
MSA	1 if angler lives in a metropolitan statistical area; 0 if not
Race	1 if nonwhite; 0 if white
Other fishing	1 if angler fishes other types of waterbodies; 0 if not
Middle Tennessee reservoir choices	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 26
East Tennessee reservoir choices	5, 8, 13, 14, 17, 18, 20, 21, 25, 26, 27, 30, 32, 34
Reservoirs with consumption advisories	14, 21, 25, 26, 30, 32

creases the probability that all reservoirs with advisories currently in place will be chosen. In particular, Watts Bar Reservoir has an increased probability of 2.1%. If Watts Bar is the only reservoir cleaned up, the probability it will be chosen increases by 3.43%.

Repeated Discrete Choice Models

The RDC model adds the decision of whether or not to go reservoir fishing; only if the decision is to fish in reservoirs will the angler reach the site choice decision. With the exception of the *inclusive value,* economic theory does not guide the selection of variables influencing the reservoir fishing decision stage. Because of difficulties in characterizing the full range of alternative activities, angler characteristics were used. These variables include the angler's age, whether the angler lived in an urbanized, metropolitan statistical area (*MSA*), race, and whether the angler fished other types of water bodies such as small private ponds, trout streams, or warmwater streams (*other fishing*). Except for *other fishing,* no priors were held for the expected signs of these variables. A negative sign was expected for *other fishing:* commitment to other modes of fishing reduces the number of choice occasions available for reservoir fishing.

In comparing the site choice coefficients of the repeated nested logit model (table 3) with those from the MNL model (table 2), recall that the RDC model scales the coefficients by $1/\mu$. After adjustments for this scaling, the site choice coefficients for both MTN and ETN did not change appreciably by adding the fishing decision to the model. All scaled site choice coefficients in the repeated nested logit model retain the same sign and are of the same magnitude relative to the simple site choice model. With the exception of *catch rate* in MTN, all variables remain statistically significant.

Table 2. MNL Site Choice Models

	Middle Tennessee	East Tennessee
Travel cost	−0.036 (−42.02)	−0.039 (−40.62)
Catch rate	0.019 (2.74)	0.073 (10.27)
Number of ramps	0.020 (18.51)	0.026 (11.45)
Consumption advisory	−0.863 (−7.33)	−0.232 (−3.05)
Percy Priest intercept	0.144 (2.52)	
Watts Bar intercept		0.513 (4.512)
No. of observations	143	135
Percentage change in probability of visitation in response to removal of advisories on all reservoirs in a region		
Reservoir 14	2.55%	0.10%
Reservoir 21		0.90%
Reservoir 25		0.45%
Reservoir 26	1.68%	0.37%
Reservoir 30		0.40%
Reservoir 32		2.13%

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

Table 3. Repeated Nested Logit Model

	Middle Tennessee	East Tennessee
	Reservoir Site Choice Decision	
Travel cost	−0.005 (−4.06)	−0.005 (−3.62)
Catch rate	0.002 (1.54)	0.011 (3.47)
Number of ramps	0.003 (4.14)	0.004 (3.54)
Consumption advisory	−0.121 (−3.71)	−0.029 (−2.36)
Percy Priest intercept	0.032 (2.76)	
Watts Bar intercept		0.073 (2.82)
Reservoir Fishing vs. Other Activities Decision		
Intercept	2.890 (32.70)	2.456 (20.96)
Inclusive value (1/μ)	0.149 (4.08)	0.137 (3.68)
Age	0.001 (−5.66)	0.001 (0.80)
MSA	−0.290 (−5.28)	−0.216 (−4.60)
Race	−0.186 (−2.13)	0.305 (3.68)
Other fishing	−0.156 (−3.32)	−0.238 (−5.28)

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

The reservoir fishing stage measures, on each choice occasion, the probability that the angler will choose to fish in a reservoir as opposed to engaging in some alternative activity. The *inclusive value* was positive and significant in both regions, as expected. The variable for *other fishing* was negative, as expected, and was also statistically significant. An angler's age was positively related to the decision to go reservoir fishing but was significant in only the MTN region. The remaining variables, *MSA* and *race,* differed across the two regions. Among MTN reservoir anglers, those living in MSAs and those who were nonwhite were less likely to fish in reservoirs on any given choice occasion, while the results for ETN were precisely the opposite. It is not immediately clear why *MSA* and *race* differ across the two regions. The major urban areas in each region (Nashville, Knoxville, and Chattanooga) all have large, nearby reservoirs, so proximity is unlikely to have effects that are not captured in the *inclusive value.* The regions all have similar proportions of nonwhite residents. The differing results, however, indicate that reservoir angler behavior is different across the regions, suggesting that the regional approach adopted for the analysis was appropriate.

Consumer Surplus Estimates

Given the negative relationship between fish consumption advisories and site choice decisions, economic losses associated with advisories can be estimated by simulating removal of the advisories from reservoirs within the site choice set (table 4). The MNL models yield surplus measures for a single trip. The per trip loss in consumer surplus is estimated as

$$\text{Per trip loss} = \frac{\ln \sum \exp[V(TC,Q^0;A)] - \ln \sum \exp[V(TC, Q^1;A)]}{-\beta_{TC}},$$

where TC is the travel cost, Q^1 and Q^0 are the "without" and "with" advisory situations, **A** represents all other arguments of the site choice model, and β_{TC} is the coefficient of the travel cost variable from the site choice model. For the MTN region, using advisories in lieu of mitigating the source of damage (cleaning up PCBs, dioxin, etc.) on two reservoirs gives losses to anglers of $1.85 per trip. The average surplus per trip in MTN is $23.60, so the loss represents about 8% of per trip consumer surplus. For the ETN region, the losses due to advisories on six of the fourteen reservoirs in the choice set is estimated at $2.86 per trip, or just over 6% of per trip consumer surplus on average. The most popular reservoir in the region, Watts Bar, is under a fish consumption advisory, so the removal of an advisory on this reservoir only is also estimated. The loss of consumer surplus due to the advisory on only Watts Bar is about $1.59 per trip.

The surplus estimates from the site choice model do not account for changes in seasonal use (changes in trip allocation and aggregate visits).

Table 4. Consumer Surplus Estimates for Removal of Fish Consumption Advisories

	Per Trip Benefit[a]	Seasonal Benefit[b]
Middle Tennessee, remove all advisories (2 reservoirs; 5.6% of all MTN reservoir fishing trips)	$1.85 ($1.45–$2.21)[c]	$21.96 ($16.36–$27.50)
East Tennessee, remove all advisories (6 reservoirs; 51.3% of all ETN reservoir fishing trips)	$2.86 ($1.07–$4.65)	$47.40 ($10.38–$88.20)
East Tennessee, remove Watts Bar advisory (1 reservoir; 30.5% of all ETN reservoir fishing trips)	$1.59 ($0.54–$2.67)	$27.60 ($5.73–$52.88)

[a]Calculated from multinomial logit site choice model.
[b]Calculated from repeated nested logit model.
[c]95% confidence interval using Krinsky-Robb (1986) method.

The RDC model does incorporate such changes, where the seasonal loss in consumer surplus is determined according to

Season Loss =

$$D \times \frac{\ln\left[\exp\left(\frac{1}{\mu} IV_i^0\right) + \exp(\alpha' \mathbf{Z}_i)\right] - \ln\left[\exp\left(\frac{1}{\mu} IV_i^1\right) + \exp(\alpha' \mathbf{Z}_i)\right]}{\beta_{TC}},$$

where the superscripts 1 and 0 refer to the "without" and "with" advisory situations, D is the number of choice occasions (184 days in this application), and IV_i^j is the inclusive value in situation j for person i, Z_i are the other arguments of the reservoir fishing decision, and $1/\mu$ and $\boldsymbol{\alpha}$ are estimated parameters.

The RDC model for MTN indicates that the mean seasonal losses to MTN anglers of advisories on two reservoirs in the choice set is $21.96. In the ETN region, the mean seasonal loss due to advisories on six of the fourteen reservoirs in the choice set is $47.40. The mean loss of consumer surplus due to the advisory on the most popular reservoir in the region (Watts Bar) is $27.60 per season. The only estimates against which to compare these figures are those of Montgomery and Needelman (1997) and MacDonald and Boyle (1997). Montgomery and Needelman found that the per capita losses due to toxic contamination of lakes and ponds in New York State were about $63 per year in 1989. While the resource being valued is similar (reservoirs vs. lakes), this figure is not directly comparable to ours because the Montgomery and Needelman estimates are for the full state population and the complete set of lakes and ponds in New York. MacDonald and Boyle used contingent valuation to gauge the effect of a mercury advisory on all open water fisheries in Maine. The advisory was estimated to reduce the seasonal value of open water fishing by $151 to those anglers who modified their fishing behavior in response to the advisory.

Conclusions and Future Research

Conclusions

In contrast with much of the fisheries literature, this paper has measured a statistically significant response by reservoir anglers to fish consumption advisories. In particular, anglers are less likely to choose to visit a reservoir with an advisory than a similar reservoir without an advisory. Furthermore, economic losses are quantified for reservoir anglers in two regions of Tennessee. Losses to MTN reservoir anglers are estimated as $22 per season, whereas ETN reservoir angler losses are about $47 per season. These figures can be used in policy analysis where consumption advisories are an option in lieu of environmental remediation.

For example, Watts Bar Reservoir is polluted with PCBs, mercury, and Cesium-137. The remediation options considered were (1) "no action," using no controls or advisories, (2) "institutional control," under which fish consumption advisories and prohibitions on dredging would be issued, and (3) "full remediation," dredging and removing 5,000 acres of sediment from the lake bottom at an estimated cost of $16 billion (1994 dollars). The cost of full remediation was considered prohibitive and the "institutional control" option was selected without considering the benefits of full remediation.

An aggregate annual benefit estimate for remediation (or the annual cost to anglers of continued advisories) can be obtained by multiplying the seasonal benefit estimate by the number of reservoir anglers in the region. Using the mean seasonal cost of advisories, a base of 146,450 reservoir anglers (calculated using the reservoir fishing participation rate determined from survey data), and a 5% interest rate, losses to anglers in perpetuity are approximately $81 million, far less than the cost of the full remediation option. Some $15.9 billion in additional benefits would be required to make the full remediation option satisfy a traditional benefit-cost criterion. If the bulk of pollution costs are borne by reservoir anglers (we have excluded the health effects of continued consumption of contaminated fish, increased participation by those not currently fishing reservoirs, and all nonuse values), rejecting the full remediation option was appropriate.

Future Research

The scope for future research remains large. First, this study measures only one form of averting behavior in response to fish consumption advisories—that of choosing to fish a different reservoir. As noted above, however, anglers have a broader variety of responses available to them, including changing the way in which fish are prepared for consumption, changing the targeted species but still fishing the same waterbed, or decreasing consumption of contaminated fish. A survey designed with the express purpose of eliciting the full range of angler response could capture losses associated with these actions. Second, we have not distinguished between "sport" anglers—those who simply catch and release without consuming fish—and "consumption" anglers, those who do consume some of their catch.[10] Given that fish stocks may respond positively to consumption advisories, "sport" anglers may actually benefit by consumption advisories because the quality of the fishing experience is "better" as the number of quality fish increases. Finally, future studies may distinguish between "degrees" of warning. Consumption advisories are not sorted by the type of species, source of pollution, and "instructions" to avoid the hazard (consume no fish of a particular species, no more than 1.2 pounds per month, etc.). It is possible that anglers adjust behavior and site choices in response to the perceived degree of hazard as contained in the recommended consumption levels.

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[10] One could estimate separate models for consumption and sport anglers, but the sample in each region was too small.