Estimating the Value of Variations in Anglers' Success Rates: An Application of the Multiple-Site Travel Cost Method

Karl C. Samples

University of Hawaii
Honolulu, Hawaii

Richard C. Bishop

University of Wisconsin
Madison, Wisconsin

Abstract An estimation method is presented to measure sport fishermen's valuation of exogenous changes in fishing quality (catch rates). A theoretical model is initially presented to show how variations in prevailing catch rates influence an angler's valuation of recreational fishing. A two-stage estimation approach is suggested that capitalizes on the notion that angler consumer surplus is sensitive to changes in success rates. The procedure entails first estimating sportfishing values at qualitatively different fishing sites using a multiple-site travel cost approach. Afterward, the sensitivity of estimated values to different success rate levels is measured using a separate regression procedure. An empirical application of this two-stage method to Lake Michigan sportfishing is given. It is estimated that for Lake Michigan anglers who fish for trout and salmon, a 10% increase in success rates will increase average trip values by $US 0.30.

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More often than not, public decisions that affect environmental resource service flows entail incremental changes in the quality of service rather than radical shifts in overall service supply. Recognition of this fact has spurred serious interest in estimating the welfare consequences of perturbations in recreational resource quality. In this regard, effort has recently been expended on determining the value to recreationists of marginal changes in perceived water quality (Bouwes and Schneider 1979), instream water flow rates (Daubert and Young 1981), and levels of congestion (Cicchetti et al. 1976; McConnell 1977; Menz and Mullen 1981). Related attempts have also been made at measuring the welfare gains and losses associated with variations in harvesting rates of waterfowl (Miller and Hay 1981; Hammack and Brown 1974), pheasants (Shulstad and Stoevener 1978), and fish (Stoevener et al. 1972; Vaughan and Russell 1982; Stevens 1966). Out of these and other studies, two basic approaches to the marginal valuation question have emerged: either recreationists are queried directly about their willingness to pay for service quality increments and decrements, or marginal valuations are imputed from information about recreational demand. Attention in this paper is focused on the second valuation approach. Specifically, a two-step method is proposed that capitalizes on the notion that the demand for recreational fishing is quality sensitive. The suggested procedure entails first estimating sportfishing values over a range of quality (success rate) levels using a multiple-site travel cost model. Afterward, the sensitivity of estimated values to different levels of success rates is measured using a separate regression procedure. An empirical application of this two-stage method is provided to show that the value of changes in anglers' success rates can be determined in this manner.

A Theoretical Model

Before discussing details of the statistical estimation procedure, we will first briefly outline the conceptual framework underlying our approach.

Let an individual recreational fisherman's preference maximization problem be stated as

$$\max U(Q, S, \overline{Z}, \overline{X})$$

subject to

$$Y \geq (\overline{P} \cdot \overline{X}) + (P_Q \cdot Q)$$

where Q is annual fishing trips, S is fishing success rate (number of fish landed in a given time period), $\overline{Z}$ is a vector of other factors which affect fishing quality (such as congestion, weather, and water quality), $\overline{X}$ and $\overline{P}$ are vectors of other goods and their prices, P_Q is the unit cost of a fishing trip, and Y is angler income. Throughout this entire presentation, S will be treated as exogenously determined and therefore independent of Q for the individual, and unaffected by aggregate fishing pressure as well. This presumption is plausible in many recreational fishing contexts where either levels of harvest are small relative to the standing fish stock, or fish density is maintained through artificial propagation or stocking programs. However, it clearly unsatisfactory when S and Q are interrelated through a stock externality effect (Anderson 1983). The maximum utility achievable at any particular set of prices, income, and fishing quality factors $(S, \overline{Z})$ is given by the indirect utility function V, where $V = V(\overline{P}, P_Q, Y, S, \overline{Z})$.

The dual to the angler's utility maximization problem is

$$\min (\overline{P} \cdot \overline{X}) + (P_Q Q)$$

subject to

$$U(Q, S, \overline{Z}, \overline{X}) \geq V^O$$

where $V^O = V(\overline{P}^O, P_Q^O, Y^O, S^O, \overline{Z}^O)$, and $\overline{P}^O, P_Q^O, Y^O, S^O$, and $\overline{Z}^O$ are initial parametric values. The cost-minimizing outlay to achieve V^O is given by an expenditure function E, where $E = E(\overline{P}, P_Q, S, \overline{Z}, V^O)$.

The welfare effects of an exogenous shift in fishing quality can be conveniently stated in terms of indirect utility and expenditure functions. Let CM' be the compensating measure of the welfare gain associated with a discrete exogenous increase in success rates from S^O to S'. By definition,

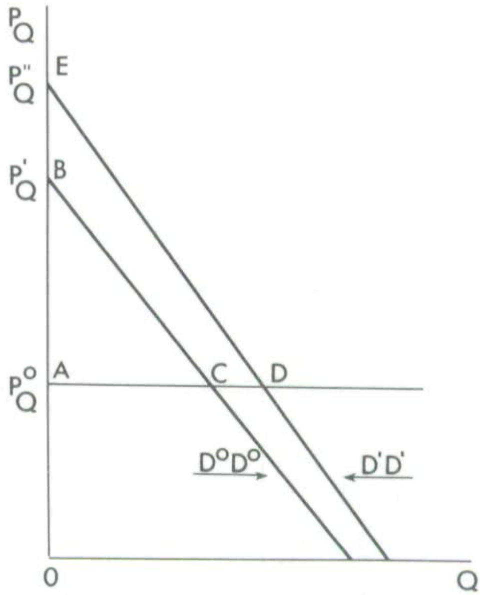

FIGURE 1. The effect of a change in success rates on fishing value.

$$CM' \equiv E(\overline{P}^O, P_Q^O, S^O, \overline{Z}^O, V^O) - E(\overline{P}^O, P_Q^O, S', \overline{Z}^O, V^O) \quad (1)$$

The meaning of this identity can be readily expressed with the aid of a simple diagram. In Figure 1, the curve D^OD^O depicts an angler's income-compensated demand for fishing trips when success rate S^O is experienced. Angler demand for fishing trips when S' is experienced is represented by the curve $D'D'$. It is assumed that fishing trips can be taken at a constant price equal to P_Q^O regardless of whether S^O or S' prevails.

The compensating variation in angler income associated with the initial level of success rate S^O is given by the area ACB. Letting this area be denoted by R^O, it follows from the properties of expenditure functions that

$$R^O = E(\overline{P}^O, P'_Q, S^O, \overline{Z}^O, V^O) - E(\overline{P}^O, P_Q^O, S^O, \overline{Z}^O, V^O) \quad (2)$$

Similarly, after success rates have exogenously increased to S', angler compensating variation is given by the area *ADE*. This area, denoted by R', can be expressed as

$$R' = E(\overline{P}^O, P''_Q, S', \overline{Z}^O, V^O) - E(\overline{P}^O, P^O_Q, S', \overline{Z}^O, V^O) \quad (3)$$

The net welfare effect association with the increase in success rates appears to be given by the area *BCDE*, of the difference between R' and R^O:

$$\begin{aligned} R' - R^O = {} & [E(\overline{P}^O, P''_Q, S', \overline{Z}^O, V^O) - E(P^O, P^O_Q, S', \overline{Z}^O, V^O)] \\ & - [E(\overline{P}^O, P'_Q, S^O, \overline{Z}^O, V^O) - E(\overline{P}^O, P^O_Q, S^O, \overline{Z}^O, V^O)] \quad (4) \end{aligned}$$

Consistency between equations 1 and 4 has been discussed elsewhere by Mäler (1974; see also Freeman 1979). It has been shown that the area *BCDE* represents an exact measure of CM' if it is assumed that S is a weak complement of Q. Essentially, the weak complementarity assumption stipulates that when the quantity demanded of fishing trips is zero, the demand price for success rates also equals zero. Provided this condition is met, then $E(\overline{P}^O, P''_Q, S', \overline{Z}^O, V^O) - E(\overline{P}^O, P'_Q, S^O, \overline{Z}^O, V^O) = 0$. Hence, equation 4 can be simplified as

$$\begin{aligned} R' - R^O = {} & E(\overline{P}^O, P^O_Q, S^O, \overline{Z}^O, V^O) \\ & - E(\overline{P}^O, P^O_Q, S', \overline{Z}^O, V^O) \equiv CM' \quad (5) \end{aligned}$$

From equation 5 it is clear that the welfare implication of an increase (or decrease) in prevailing success rates can be expressed as the difference between the relevant areas beneath two Hicksian demand curves for fishing trips, one for each level of success rate.

This finding can be stated more generally in the following manner: Let $R = R(\overline{P}, P_Q, S, \overline{Z}, V^O)$ represent an angler's compensating variation in income associated with recreational fishing. Assuming again that success rate is a weak complement of fishing trip excursions, the welfare impact of a marginal shift in success rates can then be written as

$$\frac{\partial R}{\partial S} = \frac{-\partial E(\overline{P}^O, P_Q^O, S, \overline{Z}^O, V^O)}{\partial S} = h^{-1}(\overline{P}^O, P_Q^O, S, \overline{Z}^O, V^O) \tag{6}$$

where $h^{-1}(\ldots)$ is the angler's inverse income-compensated demand function for success rate. This function indicates the angler's marginal demand price associated with various levels of success. Alternatively, it gives the amount which an angler would theoretically be willing to pay (accept in compensation) for a marginal increment (decrement) in prevailing success rates, and all the while leaving utility constant at V^O.

A Measurement Approach

A premise shared by many recreation valuation practitioners is that social values of hunting and fishing activities are related to prevailing success rates. In certain instances it is further postulated that estimates of the value of sport harvests *per se* can be gleaned from information about recreational demand. Both of these precepts remain central to the estimation method we will now outline.

Recall for a moment the theoretical relationship between the value of recreational fishing R and success rates S. In a general form it can be written as

$$R = R(\overline{P}, P_Q, S, \overline{Z}, V) \tag{7}$$

Estimating equation 7 within the framework of a statistical model is of immediate concern here. This endeavor is made slightly complicated by the fact that two separate tasks must be accomplished. To begin, a sample of observations for all dependent and independent variables must be collected. For most sport fisheries this will probably entail having to measure angler benefits at different levels of success rate because suitable data sets have not as yet been constructed. Two possible procedures to collect these data can be suggested. One way is to estimate aggregate demand for fishing and measure anglers' sport fishing values over the course of several fishing seasons, as average success rate is subject to variation. However, collection of a time series where adequate variation in success rates is manifested may prove to be a time-consuming and impractical alternative. It may also be an invalid procedure if angler preferences are especially dynamic.

A more feasible alternative is to employ cross-sectional sampling techniques. The idea is to measure anglers' consumer surplus associated with various fishing sites where sites are differentiated on the basis of prevailing success rates experienced by participating fishermen. In addition to our own, at least two other measurement techniques could conceivably be employed at this juncture (see Morey 1981; Vaughan and Russell 1982). Just as with the method we propose, the techniques used by Morey and by Vaughan and Russell should be viewed as experimental and in need of further validation and refinement. Morey has suggested a statistical model for estimating a recreationist's utility function where physical characteristics of recreation sites are treated as explicit utility arguments. Using cross-sectional data on skiers' site visitation behavior, Morey was able to derive a system of demand share equations associated with skiing sites of different quality. Vaughan and Russell have proposed a systematic varying-parameter modeling approach to account for site quality variation. They estimated aggregate visitation rates to fishing sites in a model where structural demand coefficients for travel cost, income, and other demand variables are treated as functions of site quality characteristics. Pooled data on anglers' visitation patterns to qualitatively different sites were used to estimate two equations (one each for catfish and trout fishing sites), from which anglers' average valuation of a fishing day could be derived.

Simultaneously estimating recreational values of different sites can also be readily accomplished using an econometric multiple-site travel cost model. The multiple-site model is a logical outgrowth of the traditional travel cost approach to demand estimation. Rather than focusing on recreational demand at a single site, the multiple-site framework allows for simultaneous estimation of a system of demand equations, one for each different site. This feature has in the past proven to be particularly useful in measuring the combined benefits associated with geographically dispersed, yet substitutable recreation sites (Burt and Brewer 1971; Cicchetti et al. 1976). Although heretofore unexplored, the multiple-site model also has convenient applications in estimating anglers' consumer surplus associated with alternative sites that have different prevailing success rates. Essentially this would be accomplished by (1) estimating a system of demand equations and (2) using the estimated system to calculate recreational fishing values R for each separate site.

After observations for R, S, P_Q, $\overline{P}$, and $\overline{Z}$ are collected for a number of qualitatively different sites, the second task is to estimate an explicit statistical model of equation 7. Resulting parametric estimates can be directly used to measure the value of changes in success rates by calculating the demand price for a one-unit change in success rates (given by $\partial R/\partial S$). Alternatively, success elasticities of anglers' consumer surplus can be derived. These elasticities, defined as

$$\zeta = \frac{\%\Delta R}{\%\Delta S} = \frac{\partial R}{\partial S} \cdot \frac{S}{R} \tag{8}$$

measure the responsiveness of anglers' aggregate monetary valuation of sportfishing to exogenous changes in success rates.

An Empirical Example

In 1979 a study was conducted of anglers who engaged in Lake Michigan trout and salmon fishing. During the 1978 fishing season, names and addresses of 846 anglers were randomly collected by creel census clerks working in 11 counties bordering Lake Michigan. For sample selection purposes, intercepted anglers were grouped according to the coastal county where they had been originally contacted. Approximately 63 anglers were randomly selected from each group to participate in a mail questionnaire survey. The overall response rate to the survey was 85%, yielding 592 usable returns. The questionnaire solicited information from each participant on county of residency, number of fishing trips taken in 1978 to each of 11 Wisconsin counties bordering Lake Michigan, and basic socioeconomic characteristics.

For demand estimation purposes, questionnaire data on angler fishing activity had to be adjusted in two ways. First, the number of fishing trips reportedly taken by each respondent was adjusted by the time percentage that the respondent claimed was normally devoted to fishing rather than other non-fishing activities while on a "fishing" trip. This adjustment helped reduce upward biases in estimates of actual participation rates resulting from the existence of multipurpose trips. Respondents were than classified according to their origin county, and a count was made of adjusted trips from each origin county $i(i = 1, \ldots, 73)$ to each coastal county $j(j = 1, \ldots, 11)$. Tabulated trips taken by sampled anglers were subsequently expanded to reflect the fishing activity of the total resident angling population. This expansion was accomplished by weighting the number of trips to each coastal county such that the resulting numerical value for total trips taken to county site j coincided with 1978 Wisconsin creel census estimates of aggregate participation rates at county j. Eleven different weights were used in this procedure, one for each coastal site. For each coastal county site, the weighting factor was applied consistently across all origins. The adjusted trip data yielded 803 (73×11) observations for quantity of trips taken per capita from origin i to coastal county site j. A total of 589 out of the 803 observations of per capita trips had zero values. These were included as legitimate observations in subsequent demand estimation.

Fishing trip prices were calculated as linear combinations of round trip mileage and time variable expenses in the following manner:

$$P_{ij} = 2(0.14D_{ij} + .W_iT_{ij})$$

where P_{ij} is the price of a fishing trip from origin county i to site j, D_{ij} is the actual one-way distance from origin county i to site j, W_i is the value of time spent in travel for residents of origin county i (assigned to be 50% of the average hourly wage for sampled anglers residing in origin county i), and T_{ij} is the travel time in hours required to reach site j from origin county i.

Observations of participation rates, fishing trip prices, and summary data on per capita income were employed to estimate per capita demands for fishing trips to each of the 11 coastal county fishing sites. Pretesting the effects of income on the demand for each fishing site showed that income variables were consistently statistically insignificant at the 0.25 level and hence were excluded from the analysis that followed. As a result, the following multiequation model was assumed to hold:

$$\mathbf{Q} = \mathbf{A} + \mathbf{G}\mathbf{P}^{-1} + \mathbf{B}\mathbf{P} + \mathbf{E} \tag{9}$$

where $\mathbf{Q}$ is an 11×1 vector of per capita demands, $\mathbf{A}$ is an 11×1 vector of equation intercept terms, $\mathbf{G}$ is an 11×11 matrix of inverse price variable coefficients, $\mathbf{P}^{-1}$ is an 11×1 vector of inverse own-price variables [i.e., $(1/P_1, \ldots, 1/P_{11})'$], $\mathbf{B}$ is an 11×11 matrix of price variable coefficients, $\mathbf{P}$ is an 11×1 vector of price variables, and $\mathbf{E}$ is an 11×1 vector of error terms.

Two features of this model formulation deserve special mention. First, notice that there are no fishing quality arguments included as explanatory variables. This reflects the fact that fishing quality at any given fishing site is constant for all participants. Since quality is assumed to vary only across sites, inclusion of a success rate variable in any particular equation would lead to matrix inversion impossibilities. Second, the full set of prices is included in every demand equation on the assumption that per capita demand at any particular site is sensitive to prices of alternative available fishing sites. Depending on site quality characteristics, it seems reasonable to expect some fishing areas to be substitutes or complements for other areas. Failure to account for the possibility of substitution (or complementarity) effects could result in biased estimates of own-price coefficients as well as spurious site value estimates (Cuddington *et al.* 1981).

The demand system given by equation 9 was estimated within the context of the following statistical model:

$$Q_{ij} = A_j + G_j P_{ij}^{-1} + \sum_{m=1}^{11} B_{jm} P_{im} + E_{ij} \tag{10}$$

where the subscript refers to county origins, and j and m refer to fishing sites. Parameters A_j, G_j, and B_{jm} correspond to matrix elements of **A**, **G**, and **B** given in equation 9. Similarly, variables P_{ij}^{-1} and P_{im} correspond to elements of $\mathbf{P}^{-1}$ and $\mathbf{P}$. The error term E_{ij} is assumed to be distributed with an expected value equal to zero and have a covariance structure given by

$$\mathbf{C}(E_{ij}, E_{mn}) = \begin{cases} \sigma_{jn}, & i = m, j \neq n \\ 0, & i \neq m, j \neq n \\ \sigma_{jj}, & i \neq m, j = n \end{cases}$$

The assumption that σ_{jn} was nonzero precluded use of ordinary least squares regression to calculate best linear unbiased estimates of system parameters. A preferred alternative was to employ a seemingly unrelated regression strategy (Zellner 1962). Zellner's two-stage generalized least squares procedure accounts for the possibility that cross-equation disturbance terms may be correlated. Consequently, it achieves consistent, asymptotically efficient estimates of all system parameters.

The statistical model given by equation 10 was also restricted so that estimated cross-price coefficients would be symmetric ($B_{jm} = B_{mj}$). In view of the apparent insignificance of income in demand determination, the restrictions were deemed consistent with theoretical notions concerning cross-price effects.

An econometric computer package called SHAZAM (White 1978) was used to simultaneously estimate the restricted multi-equation model. Final coefficient estimates with standard errors in parentheses are given in Table 1. In regard to functional forms, a specification with an inverse own-price term was ultimately chosen for all demand equations with the exception of site 6. Generally speaking, estimated coefficients for inverse price terms were significant at the 0.01 level. A substantial number of own-price and cross-price coefficients are reported as zero because it was determined that these price variables should be ex-

Table 1

Estimated Demand Equations for 11 Wisconsin Fishing Sites*

Site	Constant	Inverse Own Price	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	R^2
1	−0.7632	1.7509	0.00221	−0.00254					0.00097					
	(0.02664)	(0.28611)	(0.00115)	(0.00119)					(0.00026)					0.46
2	−0.05866	1.3299	−0.00254	0.00303	0.00118				−0.00101					
	(0.00984)	(0.09079)	(0.00119)	(0.00139)	(0.00021)				(0.00026)					0.66
3	−0.10704	1.8973		0.00118										
	(0.01304)	(0.12316)		(0.00021)										0.62
4	−0.49597	7.9050				0.00541								
	(0.07279)	(0.68468)				(0.00111)								0.53
5	−0.02512	0.72091								0.00023				
	(0.00366)	(0.03945)								(0.00006)				0.60
6	0.00311							−0.00008				0.00005		
	(0.00097)							(0.00002)				(0.00002)		0.17
7	−0.00407	0.22193	0.00097	−0.00101						−0.00119	0.00295	−0.00117	−0.00040	
	(0.00967)	(0.09122)	(0.00026)	(0.00026)						(0.00049)	(0.00048)	(0.00032)	(0.00012)	0.36
8	−0.07486	1.2946					0.00023		−0.00119	0.00309	−0.00334	0.00134	0.00047	
	(0.01274)	(0.10491)					(0.00006)		(0.00049)	(0.00084)	(0.00056)	(0.00033)	(0.00012)	0.46
9	−0.11159	1.9886							0.00295	−0.00334	0.00148			
	(0.03484)	(0.31720)							(0.00048)	(0.00056)	(0.00074)			0.29
10	−0.02535	0.60309						0.00005	−0.00117	0.00134				
	(0.00861)	(0.07124)						(0.00002)	(0.00032)	(0.00033)				0.39
11	−0.00817	0.22361							−0.00040	0.00047				
	(0.00290)	(0.02617)							(0.00012)	(0.00012)				0.32

* Standard errors shown in parentheses.

cluded from the final model specification on the basis of the mean standard error criterion. More specifically, omitted price variables were treated as homogeneous restrictions in the relevant regression equations. The null hypothesis that the mean square error of the restricted model was less than the mean square error of the unrestricted regression model was tested for each individual equation using the Toro-Wallace F-test (Toro-Vizcarrondo and Wallace 1968). In all cases, the null hypothesis could not be rejected. For this reason, restricted equations with omitted price variables were selected as the most appropriate demand specifications.

Symmetry restrictions regarding cross-price effects were also evaluated using the mean standard error criterion. In this instance, Zellner's system F-statistic was calculated to test a null hypothesis concerning the difference between restricted and unrestricted system mean square errors. The calculated F-statistic [$F(13,750) = 0.189$] led to nonrejection of the null hypothesis that the restricted model was best according to a mean square error criterion.

After having estimated the above demand equation system, the next step was to determine the annual value of recreational fishing associated with each site. To do this, a measure of anglers' consumer surplus was obtained in the following manner: First, for each ith origin, an average price per fishing trip ($\bar{P}_i$) was calculated as the simple average of round trip prices across all 11 fishing site destinations. Computed average prices (ranging from \$7.72 to \$132.36) were used in subsequent valuation analysis as surrogate own-prices for site valuation purposes. This represented one method to account for the phenomenon that relatively accessible coastal counties proximate to urban areas tend to generate larger consumer surpluses simply because of lower costs of participation. Consumer surplus for anglers residing in the ith origin was then determined for each of the jth sites by independently integrating the per capita demand equations [$Q_j(P)$] given in Table 1. More specifically, a computer algorithm was developed to calculate the following integrals:

$$R_{ij} = F_i \int_{\bar{P}_i}^{P_j^*} Q_j(P)\, dP$$

where R_{ij} is the estimated annual consumer surplus received by origin i anglers as a result of fishing at the jth fishing site at price $\overline{P}_i$, F_i is the population of origin i in 1978, and P_j^* is the demand choke price for site j. Depending on the particular site, the demand choke price P_j^* was defined as either (1) the price at which per capita demand reaches zero, (2) the price at which the demand curve assumes a positive slope, or (3) $175, an arbitrary value set $15 higher than the maximum round trip price observed across all origins. Numerical values used for choke prices in this analysis are given in Table 2. Total angler consumer surplus associated with the jth site (R_j) was then obtained by summing R_{ij} across all i origins.

Following the estimation procedure proposed in the preceding section, it was hypothesized that a significant portion of the variation in estimated annual site values could be explained by differences in fishing quality characteristics, particularly catch rates. The underlying statistical model to be tested was specified in the form

$$R_j = H1 + H2 \ln S_j + H3A_j + H4T_j + E_j \qquad (11)$$

where R_j is the estimated 1978 recreational fishing value for site j, S_j is the average 1978 success rate experienced at site j, T_j is the percentage of total trips taken by trollers at site j in 1978, A_j is a binary dummy variable indicating the geographical aesthetics of site j, Hn is the population parameter to be estimated ($n = 1, \ldots, 4$), and E_j is the error term $\sim N(0, \sigma^2)$.

Use of estimated annual site values as a dependent variable presented no special econometric difficulties. Estimates serve admirably well as dependent variables provided that they are unbiased and have estimation errors that are uncorrelated with the regression error term (as is typically the case). A semilogarithmic specification was chosen over a linear model on the assumption that $\partial^2 R/\partial S^2$ is nonzero. Other specifications which could conceivably yield the same result include full logarithmic (Hammack and Brown 1974) or quadratic (Daubert and Young 1981) models. Pretesting using alternative functional forms led to selecting a semilog model as most appropriate specification.

Table 2
Estimated Site Values and Site Quality Characteristics

Site	Demand Choke Price	Estimated 1978 Site Value	1978 Success Rate (fish/day)[a]	Locational Aesthetics (A = attractive, U = unattractive)	1978 Total Trips Taken[a]	Trips by Trollers (percent)[a]	Success Elasticity
1	$ 28.14	$541,384	0.906	A	40,011	61	0.38
2	20.95	165,483	0.885	A	27,599	23	1.24
3	175.00	205,403	0.382	A	102,238	51	1.00
4	38.22	75,390	0.258	A	47,715	41	2.72
5	175.00	100,960	0.370	A	14,021	40	2.03
6	[b]	40,190	0.486	U	87,320	23	5.10
7	175.00	19,649	0.442	U	84,513	42	10.43
8	20.46	55,731	0.396	U	78,684	29	3.68
9	36.65	129,017	0.425	U	125,893	61	1.59
10	175.00	31,299	0.398	U	69,414	48	6.55
11	175.00	20,503	0.301	U	34,923	28	10.00

[a] Schultz (1979).
[b] Demand choke price varies depending on origin.

It should be noted, however, that further experimentation with various specifications of the success rate variable in equation 11 is probably warranted. Inclusion of a binary dummy variable A stemmed from the assumption that anglers' consumer surplus is sensitive to aesthetics of fishing sites. Use of a single proxy variable, although admittedly simplistic, did enable some account to be made of stark differences in the natural amenities available at sites in northern Wisconsin compared to those in industrial urban sites further south. The variable T was included on the basis that anglers who troll for trout and salmon are generally active participants who tend to be highly dedicated to their sport. Moreover, sites with heavy use by trollers generally have relatively developed sportfishing infrastructure (boat ramps, tackle shops, and the like), a feature which is attractive to shore-based anglers as well as trollers. Consequently, it was anticipated that sites which accommodate relatively heavy use by trollers would have higher estimated consumer surplus values than otherwise. Values assigned to T, A, and S for each fishing site are given in Table 2.

The final equation estimated using ordinary least squares (standard errors in parentheses) is

$$R = \underset{(1{,}075)}{1{,}118} + \underset{(66{,}584)}{205{,}020} \ln S + \underset{(49{,}757)}{98{,}679}\, A + \underset{(178{,}840)}{585{,}840}\, T \qquad (12)$$

The adjusted R^2 and standard error of the estimate are 0.74 and 77,656, respectively. The calculated F ratio is 10.2, indicating that the equation is overall significant at the 0.05 level.

Derivation of success elasticities ξ for each of the eleven sites included in the study is a simple matter, and resulting estimates are reported in Table 2. By nature of the semilogarithmic specification of equation 12, calculated elasticities are inversely proportional to estimated site values. This accords with the hypothesis which states that the value of an absolute increment to anglers' catches is relatively greater at sites with lower prevailing success rates.

It is also possible to measure the average value of a 1% increase in prevailing success rates. By substituting mean values of T and A into equation 12 and using an average success rate of 0.47 fish per trip (the 1978 average), a success elasticity of anglers' consumer surplus equal to 1.48 is obtained. This translates into a \$2,050 addition to average site value for a 1% increase in anglers' success rates.

Some rather useful results emerge when this line of analysis is carried one step further. Suppose there was an interest in determining the value at the margin of sport-caught fish. An approximation of this value can be obtained in the following manner. First, assuming anglers' initial success rate is 0.47 fish per trip, it was estimated above that a 1% increase in S will generate a \$2,050 increase in average site value. Alternatively stated, average trip values will increase by \$0.03, assuming 64,757 trips are taken on average. Now, how many additional fish will expectedly be caught if success rates increase in the assumed manner? Quite clearly this calculation is contingent upon knowing the frequency of fishing trips to a representative site. Assuming that angler participation rates are relatively insensitive to small changes in S and therefore remain constant at 64,757 trips at a representative site per annum, then the increment to fishing quality under consideration would result in an additional 304 fish landed each year at a typical site (64,757 × 0.0047). Using this datum, it is straightforward to derive the unit value of the additional landings. If site value increases by \$2,050 when success rates are raised by 1%, and this quality improvement results in 304 additional fish landed, then it follows that the value per additional fish is approximately \$6.75 (\$2,050/304). Alternatively stated, \$6.75 is the average value of an additional fish landed given the fact that the anglers' success rate equals 0.47 fish per trip. This procedure can be repeated using a wide range of initial success rate values, and a schedule of "marginal" values of sport-caught fish can thereby be generated.

Concluding Remarks

In assessing the strengths and weaknesses of this two-stage approach, several comments deserve mention. First, the method is for the most part consistent with welfare theory and theory of consumer behavior. A notable deviation is the fact that observations for the dependent variable *R* are calculated using ordinary market demand functions (derived from actual travel cost data) rather than more theoretically appropriate Hicksian income-compensated demand functions. There is nevertheless strong support for using Marshallian consumers' surplus estimates as proxy measures for *R* in circumstances where income elasticity of fishing demand is small and *R* is a relatively insignificant portion of anglers' income. Another theoretical shortcoming relates to the fact that the method fails to account fully for collective (nonconsumptive) benefits derived from changes in success rates. Cocheba and Langford (1978), for example, might argue that an improvement in success rates may result in higher values of fishing for anglers who experience more strikes, without necessarily landing more fish. It may also benefit nonconsumptive spectators who are able to witness more fish being caught by others. Because the proposed method uses estimates of fishing values realized by active anglers as the basis for estimating marginal values for alternative success rate levels, it more than likely underrepresents the collective benefits associated with changes in catch rates. Moreover, since the method does not allow systematic identification of private and collective benefit components, the strength of this bias cannot be adequately measured. A more practical difficulty of using a multiple-site method stems from sampling errors which may bias estimates of participation rates and consequently obfuscate the actual value of recreational fishing at different sites. Use of biased site values in the second stage of the estimation approach will result in biased estimates of the success rate coefficients in equation 11.

These estimation shortcomings, which of themselves are not particularly bothersome, are outweighed by the advantages offered by the proposed two-stage method. First, the procedure circumvents the still unsettled issue of how to specify the role of success rates in fishing demand equations. Because angler benefits are calculated for each level of success rate, there is no need to estimate a more general demand model where success rate is treated as an independent variable. Second, use of a multiple-site cost framework to derive estimates for site values allows for anglers' actual market behavior to be incorporated directly into the valuation analysis. Consequently, the need to deal with the possibilities of direct questionnaire bias that may exist in contingent valuation methods is thereby alleviated.

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