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VALUES OF MARINE RECREATIONAL FISHING: MEASUREMENT AND IMPACT OF MEASUREMENT

Kenneth E. McConnell
Department of Resource Economics
University of Rhode Island
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1. Introduction

There is a rich literature in economics dealing with the inefficiencies of the competitive allocation of open access resources. Economists working in the area of outdoor recreation have devised a number of methods for simulating market demand curves for estimating social benefits. Recreational fishing, most especially marine fishing, is one of those activities competing for the use of open access resources that requires the estimation of social benefit functions.

In the absence of good information about net social benefits for open access activities, decision-makers tend to respond to measures which reflect the total level of economic activity. Decisions based on the level of economic activity can have rather severe consequences for non-market activities such as recreation. This bias is evident in the allocation of resources between marine recreational and commercial fishing. The history of fishery management in the U.S., particularly on the East Coast, is almost exclusively that of commercial fishery management. The magnitude of commercial fishing is recorded in market transations at the harvesting, processing and consumer levels and inputs such as vessel days at sea, fuel, and employment. However, for measures of the magnitude of recreational fishing, we have only the market value of inputs used in fishing such as boats, rods and reels, and other ancillary services. One result of relying on market data is to instill in policy-makers the belief that fish are most

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valuably used in the commercial sector because only in that sector is the output sold on the market.

Economists can help improve resource allocation by applying their evaluation techniques to marine recreational fishing. In this paper, I report on two approaches to evaluation: the travel cost method (Dwyer, Kelly and Bowes) and the hedonic price method (Pollak and Wachter; Brown, Charbonneau and Hay; Bockstael and McConnell). The two approaches are similar in that they rely on observed behavior rather than responses to hypothetical questions. They differ in the extent to which they assume an individual can control his environment.

Economists view the efficient allocation of fish stocks between commercial and recreational fishing as the allocation which maximizes the present discounted value of recreational benefits plus commercial benefits, subject to a constraint on the biological growth of the fish stock. The solution to this problem yields a dynamic multiplier which can be interpreted as the user cost of catching fish. The optimal allocation between commercial and recreational use can be achieved by imposing a fee per unit of catch equal to the user cost. The user cost depends upon the discount rate, the response of catch to increased stock density, the response of commercial and recreational effort to increased catch, and the change in biomass growth caused by greater stock densities (for details, see McConnell and Sutinen). No economist would argue seriously that fisheries management requires simply the computation of user cost and the imposition of a fee per pound of fish landed equal to the user cost. Yet the information required to calculate the user cost is central to decisions about fishery management, and can give direction to empirical work. In particular, we need to estimate how recreational anglers respond to changing stock densities.

2. The Household Production Function[1]

To determine the value of fish allocated to the recreational sector we need to be able to estimate the recreationist's net benefit function as it depends upon catch rates and trips. To estimate these relationships it is useful to adopt the household production function framework:

(1) $x = x(w_1)$, where x is trips and w_1 are inputs used to produce x; for example days, miles travelled, etc.

(2) $q = q(w_2,S,a)$, where q is fish caught per trip, and w_2 are inputs used to catch more fish per trip; for example, bait, time per trip, etc., S is the stock density of fish, and a is a set of attributes peculiar to the individual which affects production technology. S is a public input in the sense that it enters all anglers' production functions.

An individual's choices of trips and catch per trip can be viewed as if it were the result of a two-step maximization process. In the first stage the individual minimizes $p_1w_1 + p_2w_2$, the cost of achieving x and q, where p_i is the price vector for inputs w_i. The result is a cost function which depends on p_i, x, q, a, and S. It is assumed that S and p_i do not vary systematically across individuals. In the second stage the user maximizes utility subject to costs of the consumption bundle not exceeding income, I.

The equilibrium conditions for this two-step process are:

$$(3) \quad \begin{cases} f_x(x,q,I) = MC_x(x,q,a) \\ f_q(x,q,I) = MC_q(x,q,a) \end{cases}$$

where $f_x(\cdot)$ and $f_q(\cdot)$ are the marginal value functions for x and q, and $MC_x(\cdot)$ and $MC_q(\cdot)$ are the marginal cost functions for x and q. If the individual cannot adjust his catch rate, then $\partial q/\partial w_2 \equiv 0$, and catch rates may be considered exogenous. Then (3) reduces to $f_x(x,q,I) = MC_x(x)$ which is simply the travel cost method if $MC_x(x)$ is independent of x.

The household production function approach allows us to model the choice of several attributes which cannot be purchased directly, but can be produced through choice of site, equipment, and other decisions. This advantage does not come free. Compared with the travel cost method, the household production framework is quite demanding of data and requires a nonlinear, simultaneous equation estimation technique.

In the following two sections I present an application of the travel cost and household production function approach to data gathered from a Rhode Island survey of marine recreational fishing, conducted from February 1978 through January 1979. The example here pertains to fishing for winter flounder. As the reader will discern, the estimates presented here are not conclusive. It is perhaps most useful to consider these empirical results as an example of how one might apply the hedonic approach.

This version of the household production function is based on the idea that fishermen can increase their catch rate per trip by spending more on bait and equipment. We assume, for a given individual, that the catch rate does not vary systematically with trips (i.e., the catch rate is constant across trips per year, except for a random component). The cost of increasing trips depends on the catch rate per trip. Thus, the higher the catch rate, the higher the marginal cost of a trip. Likewise, the marginal cost of the catch rate increases if there are more trips. Let t be the constant travel cost per trip, and let c_q be the constant cost of catching a fish. Then total costs per year are given by:

$$(4) \quad C(x,q) = xt + xqc_q$$

Here we see that

$$\partial C/\partial x = t + c_q q = MC_x$$

$$\partial C/\partial q = xc_q = MC_q$$

Hence, though the marginal cost of x is independent of x, it depends on q, and similarly for the marginal cost of q.

To complete the system, we assume that the demand functions can be approximated by linear forms, so that (3) can be written:

$$(5)\quad \begin{cases} x = a_0 + a_1 p_x + a_2 p_q + a_3 z_1 + \theta_1 \\ q = b_0 + b_1 p_x + b_2 p_q + b_3 z_2 + \theta_2 \end{cases}$$

where the z_i are exogenous variables which may be different across equations. Here p_q and p_x are the equilibrium marginal costs and marginal values of x and q.

$$(6)\quad \begin{cases} x = a_0 + a_1(t + qc_q) + a_2(xc_q) + a_3 z_1 + \theta_1 \\ q = b_0 + b_1(t + qc_q) + b_2(xc_q) + b_3 z_2 + \theta_2 \end{cases}$$

where θ_i are the normally distributed disturbances. The equations in (6) can be estimated by nonlinear two stage least squares (see Kelejian), or by maximum likelihood methods. We have chosen to use nonlinear 2SLS, though the efficiency can be improved by using 3SLS.

To compute social value from (5) and (4), we solve for the marginal value functions as a function of x and q. Suppressing the exogenous variables into the constant term and solving (5) for p_x and p_q, we have:

$$(7)\quad \begin{pmatrix} p_x \\ p_q \end{pmatrix} = \begin{bmatrix} a_1 & a_2 \\ b_1 & b_2 \end{bmatrix}^{-1} \begin{bmatrix} x - a_0 \\ q - b_0 \end{bmatrix} = \begin{pmatrix} \gamma_0 \\ \beta_0 \end{pmatrix} + \begin{bmatrix} \gamma_1 & \gamma_2 \\ \gamma_2 & \beta_2 \end{bmatrix} \begin{pmatrix} x \\ q \end{pmatrix}$$

If we assume that $\partial x/\partial p_q = \partial q/\partial p_x (b_1 = a_2)$, we can write the total value associated with x and q as a line integral from (0,0) to (x*,q*) (see Burt and Brewer for details). Let the path from (0,0) to (x*,q*) be denoted Q. Then

$$(8)\quad \text{Total value} = \int_Q f_x(x,q)\,dx + f_q(x,q)\,dq.$$

To get the net social value, we have the line integral

(9) Net Value = $\int_Q [f_x(x,q) - MC_x(q)]dx + [f_q(x,q) - MC_q(x)]dq$.

Symmetry is assured by definition in the cost function but it must be imposed on the demand function. Imposing symmetry is equivalent to assuming that the product of the budget share and the income elasticity are equal for trips and catch rate.[2] This approximation we assume to hold locally.

Symmetry lets us express benefits as a path-independent line integral. Thus

(10) Net value = $\gamma_0 x + \gamma_1 x^2 + 2\gamma_2 xq + \beta_0 q + \beta_2 q^2 - tx - xqc_q$

For estimation purposes, (6) is rewritten with observation indexes:

$$(11)\quad \begin{cases} x_i = a_0 + a_1(t_i + c_{qi}q_i) + a_2(x_i c_{qi}) + a_3 z_{1i} + \theta_{1i} \\ q_i = b_0 + b_1(t_i + c_{qi}q_i) + b_2(x_i c_{qi}) + b_3 z_{2i} + \theta_{2i} \end{cases}$$

The exogenous variables are z_1, z_2, t, and c_q. The nonlinear 2SLS estimates $t + c_q q$ and xc_q as polynomial functions of the exogenous variables; in the second stage the predicted values of $t + c_q q$ and xc_q are used as instruments on the right hand side of (11). In the application here, z_1 is years of experience fishing and z_2 is the number of rod and reel combinations owned.

Table 1 presents preliminary results of the estimation procedure. These results are suggestive rather than final.[3] The equations were estimated with only 56 observations, perhaps accounting for the low t-values. More efficiency could also be achieved by accounting for the correlation between errors for the two equations. Consumer's surplus was computed on the basis of mean values of independent variables from equation (10). For a representative fisherman seeking winter flounder, consumer's surplus was computed to be \$515.

Table 1

Equation	Variable				
	Constant	Marginal Cost of Trips	Marginal Cost of Catch Rate	Experience	Rods and Reels Owned
Trips	7.68	-.117 (2.84)*	-.0087 (.61)	.015 (.57)	---
Catch Rate	2.39	-.0087 (.61)	-.025 (1.75)	---	.628 (6.2)

*t-statistics in parentheses. Results based on 56 observations of fishing for winter flounder in Rhode Island.

3. The Travel Cost Approach

An alternative to the household production function is to assume that anglers cannot vary their catch rates. The result is a single equation system where the catch rate is exogenous. However, it is still an argument of the demand function because individual attributes such as experience make catch rates vary across individuals. To use the travel cost approach we estimate with OLS:

$$(12)\quad x_i = r_0 + r_1 t_i + r_2 q_i + r_3 E_i + \varepsilon_i$$

where t_i is the cost of taking another trip, q_i is the catch per trip, E_i is the experience of angler in number of years fished, and ε_i is the random error term. This specification is fairly close to the spirit of the specification given in Table 1. The OLS results applied to (12) are

$$(13)\quad x_i = 7.1 - \underset{(2.58)}{.085t_i} + \underset{(.14)}{.015q_i} + \underset{(.42)}{.012E_i} \qquad \bar{R}^2 = .11$$

where t-statistics are in parentheses. Obviously this equation leaves something to be desired in terms of explanatory power and significance of variables. It is worth noting that r_1 changed little with specifications involving different independent variables.

Consumer's surplus in the single equation case is computed as the area under the demand curve and above the cost line. Computed for mean values of independent variables, consumer's surplus for a representative individual is \$233. Although equation (13) is statistically quite weak, the estimate of consumer's surplus is fairly robust because of the stability of the slope of the demand curve for specifications with other independent variables.

Consumer's surplus for the single travel cost equation case (\$233) is less than half that for the household production equations (\$515). In addition to substantial uncertainty about coefficients of the equations, there are two reasons why the household production function estimates more consumer's surplus. First, the quality variable is complementary to trips, and to the extent that cost of quality and the cost of trips are positively correlated, omitting the cost of quality will result in a downward bias for consumers' surplus. (This result is the converse of Burt and Brewer's finding that value estimate will be biased downward if relevant substitutes are omitted [p. 819]). If an individual can effectively choose quality as well as trips, then the mythical perfectly discriminating monopolist can extract rent from him in two dimensions of choice.

Our results can be used for policy by measuring the change in consumers' surplus induced by changes in the density or availability of fish stocks. For the single equation case we need to know the relationship between fish stock densities and catch rates (q_i). Then the marginal value of a one period change in the stock of fish can be computed by taking the product of the marginal value of the catch rate and the Δcatch rate/Δfish stock. Conceptually, this task is relatively simple. It is even reasonable to imagine that one could measure the relationship between densities and catch rates (see Stevens, for example). However, equation (13) is too weak empirically to justify such computations.

The household production framework can be used for policy analysis if we know the relationship between the cost of catching another fish (c_q) and fish stock density. Then the marginal value of a one period change in fish stock density is the product of $\Delta c_q/\Delta$fish stock and the change in consumer's surplus induced by changes in c_q. It is possible to design an experiment to show how c_q (or other costs) might change as the density of fish stocks change. However, no such efforts have been attempted for recreational fisheries.

4. Evaluation

In the previous section I have shown that there are substantial benefits from marine recreational fishing. Regardless of our measurement technique, we know that marine anglers receive benefits for the right to fish, and that those benefits increase as they catch more fish. The evidence at this time is by no means solid enough to compete with the commercial price of fish, but it is growing stronger (for example, we have similar evidence from Goodreau, Stevens, and Talhelm).

With this evidence we should expect a willingness by marine policy makers at the national level to provide increasing portions of annual yields for recreational purposes. However, there is evidence that recreational fishing is still a second cousin to commercial fishing. A document reflecting the Department of Commerce's view of fisheries policy states "First priority has been placed on commercial fishing because of its importance" (U.S. Department of Commerce).

Economists have devoted substantial effort to devising methods of reflecting the social value of harvesting fish for recreational use. Yet many economists have found that policy makers see little connection between social benefits, as measured by economists, and resource allocation. Why are economists' measures of social welfare difficult to accept?

(1) Many decision-makers are basically mercantilists. They choose projects on the criterion of total expenditures, rather than net benefits. At the regional level, one can make some sense out of such a policy because it implies maximizing the region's balance of trade surplus. However, at the national level there is no legitimate reason for choosing on the basis of expenditures. Nevertheless, policy makers are much more interested in estimates of expenditures than total value.

(2) Decisions are made on the basis of the "do no direct harm" thesis (see Schultze, pp. 23-24). On that basis, the harm to commercial fishing interests from reducing their catch is obvious. The damage done to recreational fishermen, particularly when they do not support a substantial service sector, is not visible when one measures the damages by the change in the value of market transactions.

(3) Economists have not measured the producers' surplus associated with harvesting fish commercially. Many fishermen are attracted to fishing as a way of life. A substantial but unmeasured social loss may occur when fishermen are forced to leave fishing for other occupations. The prospects of this loss by the fishermen generates much political pressure to ensure that commercial fishing effort is not reduced.

It is a difficult task to argue that society may be better off with a greater recreational harvest simply because sports anglers are willing to pay more for the additional fishing than commercial fishermen must be paid to compensate them for not fishing. It is difficult because we have few measures of changes in willingness to pay from changes in fishery policy.

It is difficult because decision-makers use many types of measures of welfare, and are as interested in equitable changes as in Pareto-optimal changes.

What can economists do to improve resource allocation? The notion of Pareto optimality is central to economists' definition of improvement, but pure Pareto improvements are scarce. Hence we tend to deal with potential Pareto improvements, which may bring changes in the distribution of welfare. Economists can judge changes in resource allocation which induce welfare redistributions only by judging the relative importance of the welfare of different individuals. It is more plausible to suppose that economists can help improve resource allocation by describing as accurately and concisely as possible the implications of various management strategies. By describing the magnitude of recreational fishing in terms of catch and expenditures as well as consumers' surplus, economists can help ensure that marine recreational fishing receives fair treatment among policy makers conditioned to thinking only of commercial fishing.

Footnotes

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[1]This section is an application of the ideas on the household production function presented in Bockstael and McConnell.

[2]Testing this assumption is quite difficult. Estimates of the coefficients on income variables in trip demand equations tend to be negative or insignificant and are biased because the cost of time is excluded from the price variable and is highly correlated with income. Empirical work from fertility studies suggests that the income elasticity for the quality variable is a good deal higher than for the quantity variable.

[3]A serious difficulty with these estimates is the omission of the cost of substitutes. All anglers come from Connecticut, Massachusetts or Rhode Island, and they tend to have the same kinds of non-fishing substitutes available to them. However, substitution from one species to another is quite likely and very difficult to capture empirically. The ability to substitute among species implies that the estimates of net benefits presented here are biased upward.

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