The Determinants of Value for a Recreational Fishing Day: Estimates from a Contingent Valuation Survey

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THE DETERMINANTS OF VALUE FOR A RECREATIONAL FISHING DAY: ESTIMATES FROM A CONTINGENT VALUATION SURVEY

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ABSTRACT

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We first develop a theoretical model describing the process whereby the demand for recreational fishing days is derived from an angler's constrained utility maximization. Within this framework, we generate an empirical model which we subsequently apply to a sample of responses to a "closed-ended contingent valuation" survey (where respondents merely state whether they would accept or reject a hypothetical threshold amount, either as payment for giving up the opportunity to fish, or as a fee for the right to fish.)

We use a new estimation technique which exploits the varying threshold values to allow direct and separate point estimates of slope coefficients and error standard deviation in units comparable to the underlying unobserved valuation. Our dataset is unique in that it provides detailed objective characteristics of the angler and the catch, as well as the day's weather. Models for willingness-to-pay and for compensation demanded are estimated both separately and jointly.

The fitted models allow direct simulation of the effects of changes in fisheries management or stock size upon recreational value . This capability makes our model valuable not only for cost-benefit analyses of enhancement projects, but also for decisions regarding regulation and the allocation of the resource between commercial and recreational fishermen.

RESUME

Cameron, T.A. and M.D. James, 1986. The Determinants of Value for a Recreational Fishing Day: Estimates from a Contingent Valuation Survey. Can. Tech. Rep. Fish. Aquat. Sci. 1503: vi + 73 p.

Une analyse théorique basée sur une maximisation de l'utilisation sous contrainte donne un modèle empirique qui est appliqué à un èchantillon de 4 161 réponses à une enquête, avec évaluation des contigences en forme de questions fermées, menée auprès de pêcheurs sportifs (enquête qui comprend des détails sur le pêcheur, les prises et le temps). Une nouvelle technique d'estimation des variables dépendantes censurées permet des estimations directes des coefficients de la pente en unités comparables à l'évaluation sous-jacente inobservée. L'analyse séparée et conjointe du consentement à payer et de l'indemnité demandée ont généré des modèles étalonnés qui facilitent la simulation directe de l'incidence des variations des mesures de gestion ou de la taille des stocks sur la valeur récréative.

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1. INTRODUCTION

As recreational uses of fisheries resources assume increasingly greater economic significance, questions about the economic value of sport-caught fish frequently arise. Knowledge of this value is necessary for any assessment of the economic costs and benefits of proposed changes in fishing regulations, loss of fish habitat, enhancement planning, or the redistribution of harvest shares between sport and commercial fisheries. The economic value of the *commercial* fishery is reflected in the market price of fish caught. However, recreational fishing is in large part a non-market activity. The current fee for a license is not considered a price for angling because it is unrelated to the number of fish caught or the days fished. The value of recreational fishing is generally agreed to be correctly measured by the maximum sum an individual would be willing to pay to participate in the activity or by the minimum amount an individual would require as compensation for giving it up.

There are two basic methods for indirectly determining the economic value of an angler day. The "travel cost" method uses observed travel costs per visit to a site (from different origin points) and per-capita visitation rates from each origin to deduce the "demand" relationship between individuals' willingness-to-pay for a visit and the number of visits at each possible level of travel cost (see Clawson [1959], Burt and Brewer [1971] and Cicchetti, Fisher and Smith [1976]). While variations of this method have been developed which will take into account changes in value resulting from quality alterations (see Brown and Mendelsohn

[1984]), it would be difficult to apply any of these to the present problem, because a marine sportfishery is not confined to discrete identifiable sites. In addition, the travel cost method does not measure compensation demanded, an important consideration if the value of loss of fishing opportunities is being measured.

A second method for indirectly valuing an angler day is called "contingent valuation." An in-depth assessment of this method is provided in Cummings, Brookshire, and Schulze [1986]. Individual anglers are asked hypothetical questions about how much they would be willing to pay (WTP) for a day of fishing or conversely, how much compensation they would demand (CD) to be induced not to fish. There are three approaches to asking these questions: (i.) "open-ended", where the respondent is simply asked to name the sum, (ii.) "sequential bids", where respondents are asked whether or not they would pay or accept some specified sum (the question is then repeated using a higher or lower amount, depending on the initial response); and (iii.) "closed-ended", where the respondent is asked only whether or not they would pay or accept a single specific sum. In this third method, the sum is varied among respondents.

The third contingent valuation approach is used in our survey, since it generates a scenario similar to that encountered by consumers in their usual market transactions. A hypothetical price is stated and the angler merely decides whether to "take it or leave it," relieving him of the need to come up with a specific dollar value. It also avoids the pitfalls uncovered by Knetsch and Kahneman [1984] and Boyle *et al.* [1985], where the results from sequential bidding experiments are shown to be strongly biased by the "starting point" (the initial amount quoted). There was no noticeable bias with closed-ended questions,[1] although the resulting data are somewhat more difficult to analyze.

We describe a preliminary analysis of some of the data used in this study in Cameron and James [1986], but that paper examines only the willingness-to-pay question and emphasizes the methodology and a shortcut for approximating the estimation techniques used here. The present paper is differentiated in that it (i.) develops a comprehensive microeconomic framework, (ii.) employs the more-flexible Box-Cox transformation (rather than simple logarithms), (iii.) undertakes a systematic comparison of both willingness-to-pay and compensation demanded for the same individuals, and (iv.) demonstrates the usefulness of these models for the simulation of policy measures.

An outline of the paper is as follows. Section 2 proposes a theoretical model of the demand for recreational fishing days. In section 3 we describe the data set and the limitations it imposes on the modeling process. In section 4, we summarize a maximum likelihood estimation technique for determining parameter values and mean conditional valuations for either marginal willingness-to-pay or total compensation demanded. Section 5 examines the fitted models, section 6 compares valuation by the different methods, and Section 7 demonstrates a policy simulation.

2. ECONOMIC THEORY OF DEMAND FOR RECREATIONAL FISHING

Samples and Bishop [1980] review the state of the art in sport fish valuation up to that time.[2] They conclude that there is "no direct and easy way to properly value sport caught fish." Their own work utilizes an adaptation of a multiple-site travel cost model which first estimates a number of demand equations for different fishing "products" differentiated by success rates, and then uses the fitted demand equations to simulate the net benefits of altering the product mix by varying success rates across products.

Anderson [1980] models individual inverse demand curves for recreational fishing, where marginal WTP depends on (i.) the user days of the individual, (ii.) the average size of fish caught (which depends in turn on aggregate total user days), (iii.) the number of fish caught (again depending on total user days), (iv.) a vector of cost, price, and income parameters including fishing expenses and the price of fish on the market, and (v.) a vector of environmental and social factors related to the fishing experience. Overall, the Anderson model provides a very thorough theoretical analysis with explicit recognition of the externalities involved in a recreational fishery, but no empirical implementation is offered. Nevertheless, the paper offers many suggestions about factors which should be expected to influence willingness-to-pay; these were influential in the design of our survey questionnaire.

Our own theoretical model is similar to that developed by Cicchetti, Fisher and Smith [1976]. We assume that a given individual's demand for recreational fishing days arises as a consequence of constrained utility maximization. We use an adaptation of a Becker [1965] model wherein consumption activities are viewed as the outputs of an individual-specific production process where the inputs include both market goods and time.

Without loss of generality, we assume that the individual derives utility from the production of only two output commodities: "quality-adjusted recreational fishing days," Z_F (a hypothetical construct which adjusts the number of actual fishing days to control for variations in quality), and a composite of all other non-fishing commodities, Z_N. Each output is generated from a variety of inputs according to independent, well-behaved neoclassical production functions, given by:

$$Z_F = f_F(X_F, T_F, Q_F), \text{ and} \tag{1}$$

$$Z_N = f_N(X_N, T_N), \tag{2}$$

where X_F represents all market goods (such as travel costs, bait, beer, lunch, and outboard motor fuel) which are inputs to the production of Z_F; T_F is actual chronological time spent fishing, and Q_F may be interpreted as a one-dimensional index of a vector of fishing quality variables (such as hours of sunshine, number of fish caught, enjoyability of companions, etc.). Non-fishing commodities are produced with their own market inputs, X_N, and time allotments, T_N.

As do Cicchetti *et al.*, we further postulate that the individual producer will maximize utility subject to the constraint imposed by Becker's "full income," Y (defined as the sum of money income, wT_w, derived from time spent working, and foregone income, L, which might also be interpreted as the monetized value of non-work time). In our model, the full income constraint can be written:

$$Y = wT_w + L = P_F X_F + P_N X_N + w_F T_F + w_N T_N + R_F T_F \tag{3}$$

where w is the individual's average wage and T_w is time spent at work; P_F is the price of market inputs to fishing, X_F; P_N is the price of X_N; w_F is the price of time spent fishing; w_N is the price of time T_N; and R_F is the daily admission price (possibly zero) for each unit of actual time spent fishing, T_F.[3]

We can express the individual's constrained objective function as:

$$G = g(Z_F, Z_N) + \lambda_0[Y - P_F X_F - P_N X_N - w_F T_F - w_N T_N - R_F T_F] + \lambda_1[Z_F - f_F(X_F, T_F, Q_F)] + \lambda_2[Z_N - f_N(X_N, T_N)] \tag{4}$$

Differentiating with respect to Z_F, Z_N, X_F, X_N, T_F, and T_N yields the following set of equalities as the first order conditions for utility maximization (by elimination of the Lagrange multipliers):

$$\frac{\dfrac{\partial g}{\partial Z_F}\dfrac{\partial f_F(Q_F)}{\partial X_F}}{P_F} = \frac{\dfrac{\partial g}{\partial Z_N}\dfrac{\partial f_N}{\partial X_N}}{P_N} = \frac{\dfrac{\partial g}{\partial Z_F}\dfrac{\partial f_F(Q_F)}{\partial T_F}}{(w_F + R_F)} = \frac{\dfrac{\partial g}{\partial Z_N}\dfrac{\partial f_N}{\partial T_N}}{w_N} \tag{5}$$

Each term may be interpreted as the ratio of the "marginal utility product" (MUP) of an input (X_F, X_N, T_F, T_N, respectively) to its price, where the MUP is defined (similarly to Cicchetti *et al*), as the product of the marginal utility of the consumption good and the marginal product of the particular input in the production of the consumption good.

Several features of these optimum conditions deserve mention. The remainder of this section is devoted to a detailed consideration of the theoretical predictions of the above model for the responsiveness of the demand for fishing days to the range of factors which might influence this demand.

If we can assume that f_F and f_N exhibit the usual convexity properties, then we know that an increase in Q_F, for example, will decrease the total cost of producing any quantity of Z_F. The production of Z_F^o will now require $X_F' < X_F^o$, and $T_F' < T_F^o$. With fixed prices, it must be the case that the new cost of Z_F^o, $C'(Z_F^o) = (P_F X_F' + w_F T_F' + R_F T_F') < C(Z_F^o) = (P_F X_F^o + w_F T_F^o + R_F T_F^o)$. From a consumption perspective, the "price" of Z_F has fallen (although $C(Z_F)$ will only be linear in Z_F if f_F is homogeneous of degree one in its inputs), and this will induce the familiar substitution and income effects of a price change for the optimal consumption bundle (Z_F*, Z_N*). The decline in the relative price of Z_F will encourage some substitution of fishing for other consumption activities; simultaneously, the consumption of both "commodities" will be stimulated due to the income effects of this change (providing each commodity is a normal good). We can conclude (with simple assumptions) that optimal Z_F* will increase, but the change in Z_N* will be indeterminate. However, we can draw no such clearcut conclusions regarding the demand for *inputs* into the production of Z_F. The change in Q_F will economize on the T_F input (for any given level of Z_F output), but the increased demand for Z_F will increase the derived demand for T_F.

Whether or not T_F increases when Q_F increases will depend upon both the f_F and the g functions.

Alternately, we can consider the impact of an increase in the daily fee for fishing, R_F. This will affect (Z_F*, Z_N*) by influencing the effective price of the actual time used to produce quality-adjusted fishing days, Z_F. Input substitution away from T_F (if possible) will be encouraged, and the total cost of producing any given level of Z_F will rise. This higher price will have associated substitution and income effects upon the optimal consumption bundle. Z_F* will most likely be lower; the net effect on Z_N* will depend upon the relative strengths of the two effects (i.e. the precise character of the g function). Again, we cannot observe Z_F*, only T_F*. The input substitution effect and the consumption substitution and income effects work together to imply an unambiguous decrease in the quantity of T_F demanded.

In sum then, the theory predicts that the derived demand for T_F will vary inversely with R_F, but the relationship between T_F and the quality variable(s) is ambiguous. Whereas one might expect that an increase in fishing quality would increase the number of days demanded at any price, we must account for the possibility that quality may be substituted for quantity. The relationship between quality and quantity of fishing days must be determined empirically.

The derived demand function for T_F will clearly depend in some complex fashion upon the functional forms of the two production relationships, on the utility function, as well as on income, the average wage rate, foregone earnings, the value of time in each use (w_F and w_N), and the prices of the market inputs to production (P_F and P_N). This demand will also depend fundamentally upon explicit user costs, R_F, and upon the quality of the fishing experience, Q_F. It is these last two categories of variables upon which this paper focuses.

3. THE DATA

Our raw data consist of 4161 responses to an in-person survey of recreational fisherman conducted between July and early December, 1984, on the south coast of the province of British Columbia, Canada. A substantial proportion of marine sportfishing effort in the province is expended in this area, and sportfishing anglers account for a significant proportion of the total catch of Chinook and Coho (the salmonid species which are the preferred game fish).

Ideally, of course, we would like to formulate a derived demand function for T_F which corresponds systematically to some plausible, well-behaved concrete algebraic specification of the utility and production functions. However, this is precluded by the absence of crucial variables,[4] so we fall back upon reasonable *ad hoc* specifications for the function $T_F(P_F, R_F, Q_F)$. Despite these limitations (especially the necessity of assuming away income effects) we find some very plausible relationships among these variables. It will also be convenient to work with the "inverse" derived demand function: $R_F(T_F, P_F, Q_F)$, which we interpret as the individual's "valuation" of a fishing day, argued to depend (potentially) upon the number of days consumed, upon the price of market inputs to the fishing day, and upon a vector of quality attributes. Clearly, a richer data set would allow us to include more of the theoretically-important arguments, but in this application, they must be subsumed by the constant and the error term.[5]

The data are described in greater detail in Appendix II, so only a rudimentary description will be provided here. It should be emphasized that contingent valuation surveys are a relatively new instrument for collecting data about valuation of non-priced resources. Only two groups of researchers have published studies analyzing this type of data: Bishop, et al. [1979,1983] and Sellar, Stoll, and Chavas [1985,1986].

Two crucial questions were posed in this survey. The first asked how many days the respondent planned to go fishing between the time of the interview and "the end of next month". Once the number of days was ascertained, a predetermined randomly chosen number of dollars was multiplied by this number of days and the respondent was asked whether he would accept this total amount to give up fishing in tidal waters until the end of next month.[6] This window of time was chosen because too short a period of abstinence would make intertemporal substitution very easy, and it was felt that a time horizon of one full year was too long.[7] This question will be referred to subsequently as the "compensation-demanded" (CD) question. It is important to note that the valuations we derive for these intervals are valid only for time periods of this magnitude. It is not valid to extrapolate the abstinence period to an eternity, since we expect that there is a significant discontinuity between finite and infinite time periods.

The second important question first established the cost of the current day's fishing (bait, gasoline, boat rentals, but not equipment costing more than $100). The respondent was then asked whether he would still have gone fishing if the cost of the fishing trip had been some specific (randomly-chosen) number of dollars higher. This will be called the "willingness-to-pay" (WTP) question. It was designed specifically to allow us to examine the effects of the current day's quality variables upon valuation, since these qualities are still very fresh in the minds of the respondents.

One of the valuable and unique features of this survey is that *both* types of valuation questions were posed to each respondent. This provides an opportunity to explore the empirical evidence for verification of the theoretical equivalence (except for wealth effects) of WTP and CD. To our knowledge, such an exercise has not been attempted previously (outside the experimental economics literature).

Our model assumes that both WTP and CD depend upon a variety of factors, including the characteristics of the individual and the circumstances of the current fishing trip. The survey provides highly detailed information about the times and locations where the party fished, the species caught, their numbers, and how many fish of each type were released. Date and location were used to merge the survey data with meteorological records so that weather could also be modeled explicitly. Table 1 summarizes the means and standard deviations of the continuous variables which were available either directly from the survey responses, or were constructed from these responses.

4. METHODOLOGY

In a related paper (Cameron and James, [1986]), we describe an efficient, one-stage estimation procedure suitable for use with data collected by a closed-ended contingent valuation survey. This methodology represents a significant advance over previously utilized techniques. Here, we merely summarize the strategy and highlight its advantages relative to methods which have been used before.

First of all, if we knew the precise dollar figure each individual would be willing to pay or would demand as compensation, then straightforward linear regression analysis might be quite satisfactory as an estimation technique. However, we observe these individual valuations only indirectly, through the yes/no responses, so qualitative choice methods are clearly necessary.

When the offered amounts are varied over individuals, as they are in our survey, the yes/no responses convey some diffuse information about the amount of dispersion, σ, in the presumed underlying continuous dependent variable, Y_i (valuation). Our new technique differs from the familiar logit estimation methods (as utilized in Bishop and Heberlein [1979], and Sellar, Stoll, and Chavas [1985,1986]) in that we treat the proposed amount (the threshold, t_i) as simply one value of the continuous underlying valuation variable. Technically, the threshold value should not appear among the "explanatory" variables of the discrete regression model (as in the above papers), since it is merely a cutoff value in the distribution of the true dependent variable. This alternative conceptualization allows the separate slope and standard deviation parameters to be estimated directly, in units comparable to the underlying unobserved valuation. It also allows us to avoid completely the peril of truncation bias which is fundamental in earlier methods.

In brief, we assume that $Y_i = x_i'\beta + u_i$, where Y_i is unobserved. Each individual is confronted with a threshold value, t_i, and by his yes ($y_i = 1$) or no ($y_i = 0$) response we conclude that his true valuation is either greater than or less than t_i. Specifically, if we assume that u_i is distributed $N(0, \sigma^2)$, in keeping with the conventional regression assumption[8], then:

$$
\begin{aligned}
\Pr(\, y_i = 1) &= \Pr(\, Y_i > t_i) \\
&= \Pr(\, x_i'\beta + u_i > t_i\,) \\
&= \Pr(\, u_i > t_i - x_i'\beta\,) \\
&= \Pr(\, z_i > (t_i - x_i'\beta)/\sigma\,)
\end{aligned}
$$

where z_i is the standard normal random variable with cumulative density function Φ. Hence

$$
\begin{aligned}
(8) \qquad \Pr(y_i = 1 \mid x_i) &= 1 - \Phi((t_i - x_i'\beta)/\sigma) \\
\Pr(y_i = 0 \mid x_i) &= \Phi((t_i - x_i'\beta)/\sigma)
\end{aligned}
$$

Note that if $t_i = 0$ for all observations, we would have the conventional probit probabilities. For a given sample of n independent observations, the joint density function for the data,

$f(y|y^*, x_1, \ldots, x_p, \beta, \sigma)$ can be reinterpreted as the likelihood function:

$$(9) \qquad L = f(y \,|y^*, x_1, \ldots, x_j, \beta, \sigma)$$

$$= \prod_{i=1}^{n} \left[\left[1 - \Phi \left[\frac{t_i - x_i'\beta}{\sigma} \right] \right]^{y_i} \left[\Phi \left[\frac{t_i - x_i'\beta}{\sigma} \right] \right]^{1-y_i} \right]$$

Taking logs, we have

$$(10) \qquad \log L = \sum_{i=1}^{n} \left[y_i \log \left[1 - \Phi \left[\frac{t_i - x_i'\beta}{\sigma} \right] \right] + (1-y_i) \log \left[\Phi \left[\frac{t_i - x_i'\beta}{\sigma} \right] \right] \right]$$

Nonlinear optimization techniques may then be employed to maximize the value of this function with respect to the vector of coefficients, β, and the standard deviation of the conditional distribution of valuations, σ.[9] Appendix I provides the mathematical expressions for the gradient vector and the Hessian matrix for this likelihood function.[10] Our technique allows specifications which are much richer than those analyzed in any previously-published work. Other analyses (such as Bishop *et al.* [1983] and Seller, Stoll, and Chavas [1985,1986]) have found their specifications seriously limited by the necessity (under their approach) for numerical integration to find the area of a region defined by the logit probability curve. Their procedure generates an approximate total WTP. The slope of this function is subsequently computed to generate a fixed two-dimensional "demand curve," with no provision for this curve to shift in response to other factors which might affect demand. In contrast, our approach (like conventional regression) readily accommodates a whole range of variables which let us control for heterogeneity among anglers, different weather conditions, and variations in the catch. For a more thorough comparison of the two approaches, see Cameron and James [1986].

5. RESULTS

5.1 Willingness-to-Pay Extra for the Current (Marginal) Fishing Day

Initial trial specifications of the empirical model considered two possibilities: (i) that the unobservable valuation was linearly related to the vector of explanatory variables and (ii) that the relationship was log-linear. In the simple linear version of the model, the coefficients are in dollars per unit; in the log-linear model, they are interpreted as the percent change in valuation for a one unit change in the explanatory variable. In this sense, the coefficients of simple models can be interpreted in the same manner as ordinary regression coefficients. However, since the linear and log-linear models yield widely different marginal distributions for the fitted valuations, it seemed advisable to examine whether a more-general model would dominate both of these alternatives.

It is reasonably straightforward to incorporate a Box-Cox transformation[11] of the unobservable dependent variable by explicitly transforming the *threshold* value, t_i (not the discrete "indicator variable", y_i). Implicitly, then, we arrive at a fitted relationship between the underlying variable Y and the vector of explanatory variables which takes the form:

$$(11) \qquad (Y^{\lambda} - 1)/\lambda = x'\beta \quad \text{or,} \quad Y = (\lambda\, x'\beta + 1)^{1/\lambda}$$

This relationship means that the marginal contribution of each explanatory variable will not be simply the corresponding β parameter as in the linear specification. Instead, the marginal contribution will depend on the estimate of the Box-Cox parameter, λ, the entire β vector, and the specific vector of explanatory variables for the individual in question. Specifically,

$$(12) \qquad \partial Y/\partial x_{ij} = \beta_j\, (\lambda\, x_i'\beta + 1)^{(1-\lambda)/\lambda}$$

The Box-Cox transformation proved markedly superior, as evidenced by the magnitude of the log-likelihood function at the optimum parameter values and by the magnitude of λ and the fact that it is significantly different from both one (linear model special case) and zero (log-linear model special case).[12]

The remainder of this section is quite similar to the discussion in Cameron and James [1986], with the exception that the model now involves the Box-Cox transformation, rather than a simple log transform. This innovation is a refinement, in that the Box-Cox model is less-restrictive; the qualitative results, however, are similar. The discussion is presented in full for completeness. Table 2A provides the full set of raw parameter estimates,[13,14] as well as some descriptive statistics for the fitted incremental contribution of each explanatory variable to WTP, in dollar terms. (As can be seen from equation (12), this value will differ across respondents, since it depends not only upon the coefficients in the first column of the table, but also upon the complete set of explanatory variables and the Box-Cox parameter.)

Bearing in mind that heterogeneity among the anglers will result in some quite widely differing incremental contributions for each explanatory variable, we will utilize the exogenously weighted means in the second column of Table 2A to summarize the results for the WTP model. Other things held constant, WTP is substantially higher when the present trip was guided, and when the respondent's residence is either in Canada (outside B.C.) or outside Canada. If the respondent was fishing alone, WTP is lower, although not significantly. For weekend days, the valuation appears to be higher, probably reflecting the fact that a larger proportion of weekend anglers are engaged in full-time employment during the week. For them, opportunities to fish are fewer, and hence probably valued more highly.

The variable NDAYS83 (number of days fished in 1983) is intended to serve as a proxy for either the level of experience of the respondent, or their dedication to the sport. People who fish more frequently seem to value the days' fishing more highly, but this effect is very small and statistically insignificant.

One theoretically-important determinant of the demand for fishing days is the price of market goods used to "produce" a fishing day. We have only an inadequate proxy for this variable: the current day's fishing expenses, FEXP.[15] This variable has a small but positive effect upon WTP extra for the current fishing day. This may suggest that these market goods are complementary inputs to the "fishing day" which we are attempting to value. (Cross-price elasticities of substitution would appear to be negligible, however.)

It is interesting to note that the numbers of fish caught or kept of each type seem to offer considerable explanatory power. On average, an extra Chinook salmon caught and kept adds $5.70 to WTP. These are the preferred sportfish. When no Chinook were caught, an extra Coho contributes approximately $.71 to WTP. When Chinook were caught as well, an extra Coho actually seems to detract significantly from the value of the fishing day (by $2.73). This probably reflects the quota on number of salmon per day. If a Coho is perceived as reducing the number of Chinook which could potentially be kept, they may indeed reduce utility.

Interestingly, if the largest fish caught is a Coho, the weight of this fish (LGCO) does seem to increase WTP by $0.76 per pound (where the mean weight of the largest fish when it is a Coho is on the order of six pounds). On the other hand, if the largest fish caught was a Chinook, its weight seems to be less important to the angler's WTP. These results together tend to support the possibility that the typically much larger Chinook are valued for sport, while Coho are valued only if they are relatively large.

Some of the climatic variables are also important. Bearing in mind the hypothesis that fishing tends to be better on overcast days when bright sunlight does not force the fish to greater depths, it is not surprising that WTP varies inversely with the number of hours of sunlight and likewise with a correlated variable, the mean temperature recorded for the specific fishing area on the day of the interview. Since rainfall is negatively correlated with these other two variables, it is not surprising that its contribution is positive.[16]

As anticipated, the extent to which the respondent perceives the day's fishing experience as enjoyable makes a substantial and very significant contribution to the amount they would be willing to pay. The two enjoyment dummy variables, EVERY and EREAS, make a strong contribution.[17] The marginal contributions tell how many more dollars a respondent would be willing to pay if their subjective experience fell into either of these categories (relative to the base category, "enjoyed the fishing trip somewhat or not at all"). Note that their relative influence is plausible.

The set of monthly dummy variables with base month July all exhibit negative coefficients. (November data were only recorded for one of the four fishing areas, and the coefficient on NOVEMBER is insignificant.) It is difficult to interpret the relative sizes of the coefficients on the monthly dummy variables. That their signs are all negative, however, may reflect not only the weather, but also seasonality in the availability of fish.

The SITE dummies may also reflect the "supply" of fish, since different areas have systematically different catch rates. The dummies for three of the sites (SITE 1 (Victoria) = 0) indicate that sportfishermen in the Port Alberni area seem willing to pay an average of about $41.38 more than Victoria anglers. To a certain extent, the greater time costs required to gain access to these more remote areas will imply that only very serious anglers will be fishing there. Anglers will pay $18.78 more in Campbell River, and $25.35 more in the Sechelt area.[18]

A normal distribution has been assumed for the errors in the Box-Cox transformed WTP variable (the variability not accounted-for by the included explanatory variables). The standard deviation for the errors, in this model, is estimated to be 5.57, although, of course, this is not measured in dollars, due to the Box-Cox transformation. The remaining parameter is the Box-Cox λ itself. The very large asymptotic t-test statistic suggests that this parameter is significantly different from both zero and one, so that both the linear and log-linear models are clearly dominated. Note that a magnitude of approximately 0.5 (square-root) is generally considered to be the variance-minimizing transformation.

Some "within sample" goodness-of-fit measures for this model appear in Table 2B. Both "individual" and "aggregate" measures of prediction success are provided, with the latter usually preferred because it is sensitive to "near misses," while the individual measure is an "all-or-nothing" criterion. As emphasized by Efron [1985], however, these rates of "prediction success" cannot be extrapolated to new data, since the accuracy is biased by the use of the same data both to fit the parameters and to assess "predictive" ability.

The advantage of this methodology lies in its ability to generate estimates of slope coefficients and fitted individual values of the unobservable underlying valuation. This is an improvement over earlier methods, which could only generate approximate mean values of the univariate marginal distribution of valuations. (These mean computations were also potentially biased due to truncation of the upper tail of the fitted marginal density function at the maximum offered threshold value, t_i^{max}.) Nevertheless, investigators might still be interested in the univariate distribution of valuations, and this distribution can easily be computed for WTP. Using the parameter estimates in Table 2, we find that the simple distribution of WTP has the following characteristics: mean \$43.63, standard deviation, \$21.72, median \$47.48, minimum \$4.06, maximum \$151.83, lower quartile \$30.28 and upper quartile \$63.82. This simple distribution is slightly skewed, but we know that this is due to heterogeneity among anglers.

5.2 <u>An Empirical Model for Total and Marginal Compensation Demanded</u>

The format of the CD question makes this quantity somewhat difficult to model. If we adopt the conventional neoclassical microeconomic assumption that the commodity in question is homogeneous, and we interpret the relevant flow time period as the "fishing season," then it is tempting to view the data as evidence regarding the valuation of a block of marginal fishing days.

Unfortunately, we have no data on the respondents' planned total fishing days in 1984. One strategy might make the heroic assumption that each angler fishes the same number of days each year, and we could use the NDAYS83 variable as a proxy for total days fished in 1984. We could then consider TCD/T_F (where TCD = total compensation demanded for the marginal block of fishing days, and T_F = the number of fishing days in this block) as an approximation of marginal compensation demanded at the midpoint of the interval [NDAYS83-T_F, NDAYS83]. However, fully 16% of the sample reported planned fishing days T_F which already exceed total reported days for 1983, so it is not surprising that the results for this model are less than satisfying.

Since our best approximation to a neoclassical interpretation of the circumstances pertaining to the CD variable proves unsuccessful, it is useful to explore the data for possible sources of this apparent inconsistency with conventional theory. An alternative analytical framework might be as follows:

a.) anglers consider past fishing days to be "sunk." Past fishing days may not be considered as good substitutes for (already planned) future fishing days.

b.) the CD question proposes the forfeiture of fishing days only "until the end of next month." Perhaps potential future fishing days after the end of next month are good substitutes for fishing days in the intervening period. The individual's valuation of fishing days in this intervening period can be expected to depend upon the availability of these substitutes. If fishing days in the next season are markedly less-good substitutes, we might adopt the number of remaining potential fishing days until, say, December 15, 1984 (after the hypothesized restricted period) as a proxy for the availability of substitutes.

The model for TCD described in the following paragraphs imposes these assumptions.

Recall that the WTP question pertains to the current fishing day. Individuals are asked whether they would still have "demanded" this fishing day if the cost had been a certain number of dollars higher. In economic terms, this question is addressing the value of a marginal fishing day. (Furthermore, the respondent knows with certainty the circumstances of this fishing day and the characteristics of the catch.) On the other hand, the CD questions attempt to infer the total value of a whole block of fishing days (where, in addition, the true circumstances of these future trips and the catch are unknown to the angler). If the utility derived from an extra fishing day decreases as the number of days of fishing increase, then we would generally expect the value of the last day fished to be less than the average value of all fishing days. The following model attempts to discern marginal valuations from the TCD information provided by the survey. (At the outset, however, it should be noted that efforts to estimate marginal valuations via differentiation of a fitted total valuation curve will be highly dependent upon the functional form chosen to represent the total curve.)

Before the model can be estimated, it is necessary to correct in an admittedly arbitrary way for the differences in the lengths of the time horizons faced by each respondent in the CD question. We let HOR (horizon) be the number of days "from now until the end of next month." We then standardize HOR to a typical 31-day month, which of course requires the strong assumption that planned fishing days are distributed evenly over the time horizon. This is unlikely to be true, but must be imposed for tractability.[19] Another consideration is that respondents who indicated no planned fishing days over the relevant time horizon had to be excluded. This criterion deleted 504 responses.

Different respondents report differing numbers of planned fishing days over the relevant time horizon. We will assume that this number of days is the optimal number of days for each fisherman, given all other prices and income. For implementation, we desire a simple mathematical formulation for TCD. This form should accommodate a downward-sloping demand (MCD) curve. One candidate is a log-log specification, but this imposes a high degree of skewness in the fitted values of MCD. Consequently, we adopt instead a model which utilizes again the Box-Cox transformation of the implicit dependent variable. The transformed value of TCD will be hypothesized to depend upon the log of the number of planned fishing days, T_F (for which DAYS/HOR*31 is the empirical counterpart), as well as on a vector of anticipated average fishing day characteristics, Q_F (all of the other measurable variables in the model).[20] A reasonable initial specification might be:

$$(13) \quad (TCD^{\lambda} - 1)/\lambda = \beta_0 + \beta_1 \log T_F + \beta_2 Q_F + \epsilon$$

Parameter estimates for the fitted Box-Cox transformed TCD model[21] are presented in the first column of Table 3A. TCD itself may then be expressed as:

$$(14) \quad TCD = [\lambda(\beta_0 + \beta_1 \log T_F + \beta_2 Q_F) + 1]^{1/\lambda}$$

The "inverse demand function" for fishing days corresponding to this total CD function is thus MCD, which is given by:

$$(15) \quad \partial TCD/\partial T_F = (\beta_1/T_F)\,[\lambda(\beta_0 + \beta_1 \log T_F + \beta_2\, Q_F)+1]^{(1-\lambda)/\lambda}$$
$$> 0 \quad \text{if } \beta_1 > 0$$

Clearly, the MCD for an extra fishing day can be seen to rely upon the vector of average expected fishing day characteristics.

For consistency with economic theory, it is important that MCD be decreasing in T_F. Simple algebraic manipulation yields:

$$(16) \quad \frac{\partial MCD}{\partial T_F} = (-\beta_1/T_F^{\,2})\,\left(1 + \beta_1(1-\lambda)[\lambda x'\beta+1]^{-1}\right)\,[\lambda x'\beta+1]^{(1-\lambda)/\lambda}$$

This expression will be negative if $\beta_1(1-\lambda)[\lambda x'\beta+1]^{-1} > -1$. If β_1 (the coefficient on log T_F = LOG(DAYS/HOR*31)) is positive, which is necessary for the MCD to be positive, then this condition is very likely to be met, since the other terms involved are also likely to be positive. The condition can easily be checked at all data points. (For our final TCD sample of 3657 observations, the weighted mean value of this *derivative* is -48.97, with a standard deviation of 84.23. The distribution of fitted values is highly skewed, however, ranging from -0.3879 to -1617.62, with a median of -26.01 and quartiles of -10.18 and -66.82.)

Policy measures designed to affect the quantity or the size of fish caught can thus be expected to affect the expected marginal valuation of an extra fishing day. The impact of these policy changes on marginal valuation can also be simulated using the fitted model for TCD. In general, the incremental contribution of each explanatory variable other than the number of planned fishing days is determined by:

$$(17) \quad \frac{\partial\ MCD}{\partial Q_F} = [\ \beta_1\beta_2(1 - \lambda)/T_F\ ]\ [\lambda x'\beta + 1]^{(1-2\lambda)/\lambda}$$

These incremental contributions of each variable to MCD will vary across observations, since they depend not only upon the estimated parameters, but also upon the data. Table 3A also gives the exogenously weighted means and standard deviations across all respondents of these incremental contributions for each of the Q_F variables.

Note that we have opted to respecify the NDAYS83 variable. It is now entered as a dummy variable indicating whether the respondent fished any days at all during the previous year. We then utilize the interaction of log(NDAYS83) with this dummy as a second variable.

It is also worth noting at this point the issue of the FEXP variable (fishing expenses under $100 per item incurred for the current day's fishing expedition). It might at first appear that the CD question ignores this expense. But recall that the WTP question addresses WTP an amount over and above these actual expenses. Presumably, respondents will realize that if they choose to forgo fishing in the future, they will also avoid incurring these fishing expenses. The CD should thus be *net* of normal per-day fishing expenses. Again, we are considering some type of measure of surplus, rather than total valuation.

Note further that since "TIME LEFT IN SEASON (after abstinence)" takes on only four different values, the monthly dummies are somewhat redundant. We have eliminated these variables and others which fail to make a significant contribution in terms of the value of the maximized log-likelihood function to arrive at our most parsimonious model which still retains the "policy" variables of interest.

MCD does indeed decrease with increasing T_F. The raw coefficients for this model are not comparable to those for the WTP model since the Box-Cox parameters are so different. However, the incremental contributions can be compared. The fishing day quality variables--providing the angler assumes that the current day's experience is representative of the mean anticipated future experience--have plausible effects when it comes to shifting the "demand curve" for future fishing days. Discrepancies between the incremental contributions of each variable in the two models seem remarkably small, given the heroic assumptions which have been made in order to estimate MCD from the TCD model. The results are qualitatively very similar so detailed comparisons are left to the reader. Once again, individual and aggregate goodness-of-fit measures for the TCD model appear in Table 3B.

As for the WTP model, it may be of interest to consider the simple univariate distribution of the fitted MCD values. This distribution is marked by a few extremely large values. Some descriptive statistics are: mean \$56.84, standard deviation \$42.34, median \$61.62, maximum \$623.63, minimum \$6.93, upper quartile \$106.78, lower quartile \$38.70. The 99th percentile is only $294.99, which conveys the degree of skewness. (Skewness is not computed directly because we are looking at the weighted sample).

6. COMPARISON OF FITTED WTP AND FITTED MCD

Cummings, Brookshire and Schulze [1986] highlight the issue of comparing WTP and MCD (which they term WTA--willingness-to-accept):

> "To date, researchers have been unable to explain in any definitive way the persistently observed differences between WTA and WTP measures. ...we know of no studies wherein posited causes of WTA-WTP differences have been systematically examined. WTP and WTA measures...are typically elicited from different groups of subjects--rather than from one subject...."

Our survey therefore, offers a unique opportunity for the assessment of differences between WTP and MCD *for the same individual*. Thus far, it has not been possible, in the context of actual field survey data, to explore the theoretical notion that these alternative measures should be similar for a given individual.

To compare the different measures for each observation, we first take the estimated parameters in Tables 2A and 3A and compute the fitted individual values of WTP and MCD (transformed back into dollar terms using the estimated parameters from the separate Box-Cox models).

The marginal distribution of the fitted WTP values, across all respondents, is quite symmetrical, with weighted mean $41.99, and standard deviation $20.59. For MCD, however, the marginal distribution is highly skewed to the right. This reflects the fact that the Box-Cox parameter indicates that the TCD function is almost log-linear. The weighted mean MCD (over the TCD sample[22]) is $56.84, with standard deviation $42.34.

It is possible to pose the null hypothesis that if MCD and WTP are indeed identical, then a simple regression of MCD on WTP would yield an intercept of zero and a slope of unity. Table 4 gives weighted OLS regression estimates for the simple regression of fitted MCD on fitted WTP (where we choose MCD as the dependent variable only because we suspect greater "errors of measurement" in this variable). Due the the long upper tail on the distribution of fitted values for MCD, we also include the same model estimated on two truncated samples: (i) with the upper percentile of both MCD and WTP deleted, and (ii) with the upper 5 percent of both MCD and WTP deleted. These latter two exercises explore the influence of "extreme" respondents. Furthermore, since an unweighted Box-Cox simple regression of fitted MCD on fitted WTP yields a transformation parameter of -0.04, we suspect that the maintained hypothesis of a linear relationship between the two fitted values is not strongly supported by the data. A fourth column in Table 4 provides the results for a weighted OLS regression of log(MCD) on WTP. While we have not corrected the R^2 values for the difference in the dependent variable, it would appear that the log-linear model performs quite well, supporting the functional form suggested by visual inspection of the plot associated with Table 4.

The observed relative magnitudes of marginal WTP and MCD are consistent with the results reported by Knetsch and Sinden [1985], where compensation measures of value seem significantly to exceed WTP measures. As Knetsch and Sinden point out, earlier analyses have presumed the equivalence of CD and WTP measures, with the exception of small discrepancies due to income or wealth effects[23] (i.e. Willig [1976], Freeman [1979]). Differences which have emerged (Hammack and Brown [1974], Rowe, d'Arge, and Brookshire [1980]) have been attributed to strategic bias by respondents or to inaccuracy in the design of surveys (Dwyer and Bowes [1978], Brookshire, Randall, and Stoll [1980]). The results from the present study suggest that "WTP" and "CD" (at least as we have measured them) can be influenced by different aspects of the fishing experience. In part, the discrepancy may be due to the retrospective aspects of the WTP question, versus the prospective nature of the average compensation question. Again, similar intuitive inconsistencies between MCD and WTP are familiar to researchers working with the value of human life. In some cases, symmetry is not expected. Extensive speculation upon possible reasons for the tendency of WTP and MCD to differ is offered in the summary chapter of the Cummings, Brookshire and Schulze book ([1986], 217-221).

One further issue concerning the relationship between WTP and MCD also concerns the fact that both valuations are estimated across the same set of respondents. To the extent that missing variables might have a common influence on valuation measured either way, it is important to consider the possibility that the error terms in the two models might be correlated. Appendix IV describes the procedure for jointly modeling WTP and TCD. For this dataset, however, it seems that the error correlation, while positive, is very small (ρ = .1887). This implies that there is little to be gained in terms of econometric efficiency by joint estimation--the separately estimated models are probably adequate. In other applications, however, the joint estimation process may prove to be essential.

7. POLICY SIMULATIONS

One of the objectives of this research is to attempt to identify the social value of the sportfishery. This is a difficult task, given the ambiguity about what exactly is being identified through the responses to the two different survey questions. If we assume that the WTP question addresses the value of a marginal fishing day to the respondent (regardless of whether they have been surveyed previously), then we cannot simply generate a scaled-up weighted sum of these valuations as our estimate of the total value of the fishery (i.e. the dollar value of welfare losses if sportfishing were eliminated entirely). Since marginal valuation increases as days of fishing decrease, this would result in an underestimate of the total value of the sportfishery. At best, we can only identify a lower bound on the value.

With an approximate lower bound on current total valuation established, however, it is possible to simulate the increase in the social value of the recreational sportfishery (due to enhancement efforts) by imposing a counterfactual change in the data upon the calibrated weighted model and computing revised mean valuations. The predicted increase in social value can then be computed by summing the revised sample valuations and scaling up to the entire population.

A second important objective of this study is to determine the incremental contribution of the fish themselves to the social value of a fishing day, controlling for as many other factors as possible which might influence that value. In this respect, our study represents a significant innovation relative to the level of detail retained in existing empirical work. Furthermore, we have managed to retain the distinction between the numbers of each of the two major species of sportfish (as well as some information, albeit limited, regarding the sizes of fish being caught, i.e. the weight of the largest fish, if the largest fish is either of the two species). Our fitted models are therefore well-suited for simulating the consequences of any measures which might influence the numbers of fish caught of each species, both for individual anglers and (by summing and scaling-up) for the recreational fishery as a whole.[24] While a variety of hypothetical policies could be examined, we have chosen as our example a simple cost-benefit analysis of an actual planned project.

7.1 An Example: Salmon Enhancement Facility Expansion

The Canadian Department of Fisheries and Oceans is presently planning expansion of a number of its salmon enhancement facilities. In one case, consideration is being given to increasing the production capacity of the Little Qualicum Hatchery by 8000 chinook per year. This expansion would have a total capital cost of $450,000 in 1986 and 1987 and operating costs of $50,000 per year. (All figures are in constant 1984 Canadian dollars.) The Department is currently using a less-sophisticated technique for estimating the anticipated benefits to recreational users of the resource. Benefits have been estimated by attempting to measure the increase in angler days that would result from the marginal addition of fish to the fishery. This increased number of fishing days was then multiplied by the *average* value of an angler day. By assuming that all increases in catch lead to additional angler days (rather than an increase in catch per existing angler day, and therefore to an increase in the value of that angler day), this previous method tended to overestimate the value of the extra fish to the recreational fishery.

We will adopt existing Department estimates for the present discounted value (PDV) of costs and for the PDV of anticipated benefits to the commercial and native fisheries. However, we will substitute the predictions of *our* model regarding recreational benefits, and recompute the net social benefits. Using the Department's Salmon Enhancement Program (SEP) evaluation model with a 10% discount rate, the following net present values of resulting costs and benefits have been calculated:

Gross Benefits:

Commercial	$ 509,000	
Native	439,000	(subtotal = 948,000)
Recreational	?	
Total	?	

Gross Costs:

Capital	$ 383,000	
Operation and Maintenance	466,000	
Harvesting	51,000	
Processing	45,000	
Total	945,000	
Net Benefits:	$?	($ 3000 even without recreational)

Thus it seems that even *without* the recreational benefits, the project would have small positive net social benefits.

Catch distribution evidence suggests that 26.6 percent of the expected total annual catch from this hatchery expansion will go into the sportfisheries which are the subject of this analysis. Benefits attributable to the increase in sport catch can thus be calculated in a fairly straightforward manner. In order to do this, catch must first be translated into an increase in catch per angler day. The Department estimates that total production will be larger by 2667 in 1986, by 5333 in 1987, and by 8000 in all years following until 2029 (the estimated lifespan of the facility). The Department has also established anticipated increases in catch per boat day in each year of the project, conditional on the assumption that fishing effort remains approximately at its 1984 level. We then divide these figures by 2.5 (the average number of anglers per boat) to achieve estimates of the change in catch per angler day. We then impose the counterfactual scenario that each respondent in our sample catches this small additional number of Chinook, and recompute each fitted willingness-to-pay. (We will use estimates from the WTP model only, partly because this is the relevant measure when we are considering adding to the fishery, but also because we have more confidence in the theoretical plausibility of the model in this case.) The change in the weighted sum of all fitted WTPs gives us our simulated increase in value due to the facility expansion.

The next step is to inflate this sum, first extending the result from our sample to the entire population of anglers, and then extrapolating from our base period of July through November to annualized estimates. The total number of angler days over our five-month period is approximately 1,163,994. (Approximately 80.5% of this effort is by Canadian residents and 19.5% by non-residents, but we have already weighted for these proportions in our calculation of total and mean WTP.) Therefore, the first inflation factor we will apply is (1,163,994/3916) for Canadian residents (where 3916 is the sample frequency in this category). For non-residents, this factor will be (1,163,994/245). In the second case, we note that for Canadian residents, an average of 65.15% of the Chinook catch in the sportfishery occurred during the five months corresponding to our survey window. For non-residents, the proportion was 74.12%. We will therefore inflate our model's predicted change in total value by 100/65.15 in the first case, and by 100/74.12 in the second. We will argue that since our model controls for seasonal effects and for weather, any adverse influence on the simulations of differences in fishing conditions during the earlier months of the year will be minimized.

Our WTP simulation indicates that the present discounted value (at 10%) of the future stream of benefits to Canadian sportfishermen will be on the order of $38,000. This component is of interest to Canadian policymakers. Additional benefits, accruing to non-residents, amount to approximately $11,000. Consequently, our estimate of the Canadian domestic social benefits for the project is $509,000 + $439,000 + $38,000 = $986,000. Therefore, the net domestic social benefits are about $41,000. Total international social benefits will be $997,000 - 945,000 = $52,000.

As a consequence of our new methodology, we can isolate the incremental contribution of the catch to total fishing day valuation. Earlier techniques which yielded only the marginal mean value of a fishing day could have done little more than simply divide this value by the average number of fish caught, to generate an approximate "average value per Chinook." Given an anticipated increase in the catch, then, one might use this average value to infer the increase in recreational benefits. It is quite clear, however, that this "average" measure will overstate the added value due to the increased catch. With our marginal mean WTP of $43.63, and our mean number of Chinook equal to about .5, an "average" value per Chinook of about $87 is implied. This is considerably larger than the marginal value of roughly $5.70 implied by our model (see Table 2A).

Of course, the net social benefits for this hatchery expansion would be positive even if there were no recreational benefits. Our simulation experiment indicates that recreational benefits will be considerably less than the commercial or native benefits, but they will still be substantial. The project *does* appear to be justified on the basis of social cost-benefit analysis.

8. CONCLUSIONS AND DIRECTIONS FOR FURTHER RESEARCH

In this paper, we have developed a household-production based *theoretical* model wherein the demand for recreational fishing days is specifically related to the quality of those fishing days, to the prices of associated market goods, and to per-day user fees. The derived demand for actual fishing days is argued to result from the individual's constrained utility maximization. This theoretical development suggests that the demand for fishing days will be inversely related to the magnitude of per-day user fees; however, the possibility of quality/quantity substitutability in the utility function means that the effect of fishing-day quality on number of days demanded is an empirical question.

In this paper, we have utilized a new maximum likelihood model for WTP and CD. These models allow components of the total valuation to depend upon a wide range of characteristics of the individual angler, the current day's catch and weather conditions. The finding that WTP and MCD are best-explained by slightly different sets of variables implies that the type of valuation we are modeling in each case could be somewhat different. Our initial results appear to conform with empirical findings in other contexts that MCD exceeds WTP. The methodological innovations allow us also to estimate conditional variances in these valuation estimates, the correlations between the fitted values, and (in the jointly estimated model in the appendix) the correlations between the unexplained components of each type of valuation.

Bearing in mind the magnitudes of the standard errors involved, we undertake an effort to approximate the total social value of the sport-fishery (the sum of the weighted sample mean valuations, scaled up to the total level of fishing effort.) We also explore rough estimates of the potential social benefits which could be expected to accrue to sportfishermen as a consequence of a specific enhancement project.

One of the most important contributions of this research is the development of a model which explicitly estimates the *marginal* contribution of catch characteristics to the value of a fishing day. Recreational anglers consistently claim that there is a lot more to fishing than just catching fish. To our knowledge, this is the first empirical analysis using closed-ended contingent valuation techniques which distinguishes the contribution of the fish from other factors which interact to generate utility for anglers.

A few limitations of this study must be acknowledged. Our research measures alterations in the value of existing days, it does not account for increases in angler days from either current anglers or new anglers. Since the survey was administered only to persons who *were* fishing, we have no means of assessing the impact of any policy measure on the decisions of potential fishermen about whether or not to go fishing at all. Our valuation models are conditional on the decision to fish in the first place. Consequently, we can only hope to place a lower bound on the social value of this resource. We are unable to quantify the magnitude of "option demand" value--the value of the resource to individuals who derive satisfaction from knowing that the opportunity for sportfishing is present, even if they do not take advantage of it. Neither can we address "existence demand", the value to non-fishing individuals who nevertheless would like the different species to be preserved or enhanced even if there were no sportfishermen at all. Furthermore, since the model does not encompass the externalities described by Anderson [1980], we can only predict the anticipated policy-induced change in social value accruing to those anglers currently using the resource. Clearly, it is not possible to model any increases or decreases in the number of anglers, or to incorporate the feedback effects of these changes on the enjoyment (and hence valuation) of the existing anglers.[25]

Despite some limitations, this paper offers an innovative approach to discerning the contribution of the catch itself to the total value of access to a sport-fishery resource. The Box-Cox transformation allows a flexible data-driven functional form for the relationship between valuation and its explanatory variables (in cases where a rigorous microeconomic model cannot be supported by the available data). Furthermore, the systematic comparison of WTP and marginal CD, for the same individuals, is a particularly significant contribution. In cases where both types of response have been elicited by closed-ended contingent valuation surveys, there is potential for improving the efficiency of the estimates by estimating both models simultaneously.

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Table 1

Descriptive Statistics for Weighted* Sample
(n = 4161)

VARIABLE	DESCRIPTION	MEAN (PROPORTION)	STANDARD DEVIATION
VALUATION INFORMATION:			
DDOFFER	compensation offered/day	48.34	35.12
TDOFFER	total compensation offered	303.75	424.22
ACCEPT	would accept compensation	0.3348	
FEXP	today's marginal expenses	30.35	41.61
ADFEXP	proposed extra expense	22.06	18.79
STILLFSH	would still fish with ADFEXP	0.7243	
CHARACTERISTICS OF RESPONDENTS:			
GUIDED	guided/not guided	0.09326	
RESROC	resides Canada (not B.C.)	0.06808	
RESOTH	resides outside Canada	0.2029	
SOLO	fished alone	0.1189	
WKND	fished on weekend/holiday	0.4855	
NDAYS83	days fished in 1983	18.82	25.04
CHARACTERISTICS OF CATCH:			
NKCN	# chinook salmon kept	0.4955	0.9977
NKCO	# coho salmon kept	0.7696	1.534
LBS	weight largest fish (lbs)	5.154	6.550
WEIGHTS OF LARGEST FISH (IF LARGEST IS EACH SPECIES)			
LGSTSALM	(1895 OBS) salmon	9.324	6.324
LGCN	(1334 OBS) chinook	12.42	6.759
LGCO	(495 OBS) coho	5.608	2.552
LGOS	(66 OBS) other salmon	9.412	5.106
LGOF	(268 OBS) other fish	5.817	5.888
MONTH OF OBSERVATION:			
JULY		0.3679	
AUG		0.3916	
SEPT		0.1964	
OCT		0.03000	
NOV	(or first days of DEC)	0.01411	
MAJOR SURVEY AREA:			
SITE1	Victoria, B.C., Canada	0.1904	
SITE2	Port Alberni " "	0.1018	
SITE3	Campbell River " "	0.4831	
SITE4	Sechelt " "	0.2247	
WEATHER:			
MEANTEMP	mean temperature (C)	15.44	3.316
TOTPREC	total precipitation (mm)	1.068	4.128
HRSUN	hours of sunshine	8.797	4.584
RESPONDENTS' SUBJECTIVE ASSESSMENTS:			
EVERY	enjoyed "very much"	0.6728	
EREAS	enjoyed "reasonably"	0.2301	
ESOME	enjoyed "some"	0.06680	
ENONE	enjoyed "not at all"	0.03030	

* Since the sample is not exactly representative of the population, we must employ exogenously determined weights. These weights are based on a 60-cell crosstabulation (RESIDENCE by SITE by MONTH) of fishing effort for both the relevant population and the sample.

TABLE 2A

Willingness to Pay Extra Amount

(MLE Estimates for Box-Cox Transformed Implicit Dependent Variable)

(n = 4161; goodness-of-fit statistics in Table 2B)

VARIABLE	COEFFICIENT (asym. t-ratio)	INCREMENTAL CONTRIBUTION TO WTP (in $) mean (st. dev.)
intercept	7.011 (4.255)	
GUIDED	4.176 (3.328)	23.47 (5.440)
RESROC	2.926 (3.756)	16.44 (3.811)
RESOTH	2.581 (3.056)	14.51 (3.362)
SOLO	-0.6819 (-1.411)	-3.832 (0.8882)
WKND	0.5413 (1.796)	3.042 (0.7051)
NDAYS83	0.02873 (3.658)	0.1614 (0.03742)
FEXP	0.008674 (1.499)	0.04874 (0.01130)
NKCN	1.014 (3.560)	5.697 (1.321)
NKCO given NKCN=0	0.1261 (0.5962)	0.7088 (0.1643)
NKCO given NKCN>0	-0.4868 (-1.938)	-2.735 (0.6340)
LGCN	0.01773 (0.7757)	0.09963 (0.02309)

cont'd...

LGCO	0.1353 (1.412)	0.7602 (0.1762)
MEANTEMP	-0.1347 (-1.760)	-0.7570 (0.1755)
TOTPREC	0.04325 (1.606)	0.2430 (0.05633)
HRSUN	-0.04841 (-1.189)	-0.2720 (0.06306)
EVERY	3.077 (4.399)	17.29 (4.009)
EREAS	1.346 (2.348)	7.564 (1.754)
AUGUST	-1.962 (-3.485)	-11.03 (2.556)
SEPTEMBER	-1.946 (-2.823)	-10.93 (2.534)
OCTOBER	-3.482 (-3.208)	-19.56 (4.535)
NOVEMBER+	-0.7757 (-0.6039)	-4.359 (1.010)
SITE 2 (Port Alberni)	7.365 (5.876)	41.38 (9.593)
SITE 3 (Campbell River)	3.343 (4.729)	18.78 (4.354)
SITE 4 (Sechelt)	4.512 (5.039)	25.35 (5.877)
σ	5.574 (6.244)	
λ	0.5349 (10.91)	

* exogenously weighted means and standard deviations computed across fitted values for entire sample (the incremental contribution to WTP of an extra unit of each explanatory variable for each respondent will depend not only upon the associated pseudo-regression coefficient, but also on the entire vector of explanatory variables, the other regression coefficients, and the Box-Cox parameter). The skewness in the unweighted fitted values is approximately -0.38 for all incremental valuations.

Table 2B

"GOODNESS-OF-FIT" SUMMARIES, BOX-COX TRANSFORMED WTP MODEL (exogenously weighted)

Willingness-to-Pay Extra (1=would pay amount, 0=would not pay)

i.) Individual Prediction Success (individual probability > 0.5):

	Observed		
Predicted	1	0	total
1	2827.63	556.06	3383.69
0	186.02	591.29	777.31
total	3013.65	1147.35	4161.00

ii.) Aggregate Prediction Success (summed probabilities):

Outcome	Predicted Frequencies	Actual Frequencies
1	3041.01	3013.65
0	1119.99	1147.35

TABLE 3A

Total Compensation Demanded

(MLE Estimates for Box-Cox Transformed Implicit Dependent Variable)

(n = 3657; goodness-of-fit statistics in Table 3B)

VARIABLE	COEFFICIENT (asym. t-ratio)	INCREMENTAL CONTRIBUTION TO MCD (in $) mean (st. dev.)
intercept	3.505 (10.79)	
GUIDED	1.676 (3.744)	48.52 (34.44)
RESROC	1.167 (3.114)	33.77 (23.97)
RESOTH	0.2083 (1.095)	6.027 (4.279)
DUM(FISHED 83)	0.2122 (0.8700)	6.142 (4.360)
LOG(NDAYS83) *DUM(FISHED 83)	0.2889 (3.101)	8.336 (5.918)
LOG(DAYS/HOR*31)	1.284 (5.148)	-
NKCN	0.3338 (3.071)	9.661 (6.858)
NKCO given NKCN=0	0.02282 (0.3414)	0.6605 (0.4689)
NKCO given NKCN>0	-0.4493 (-4.516)	13.00 (9.231)
LGCN	0.01824 (1.412)	0.5278 (0.3747)
LGCO	0.09644 (2.524)	2.791 (1.981)

cont'd...

EVERY	0.6149 (3.660)	17.80 (12.63)
TIME (after abstinence to Dec. 15)	-0.002023 (-0.7964)	-0.05851 (0.04155)
SITE 2 (Port Alberni)	2.117 (4.678)	61.26 (43.49)
SITE 3 (Campbell River)	0.7663 (3.586)	22.18 (15.74)
SITE 4 (Sechelt)	0.7623 (3.493)	22.06 (15.66)
σ	2.473 (5.457)	
λ	0.1009 (2.782)	

* the parameters in this column pertain to the effect of each explanatory variable upon the Box-Cox-transformed value of TCD (equation 13); the incremental contributions of each variable to MCD must be computed using equation (17).

** again, since the incremental contribution to MCD of an extra unit of each explanatory variable will depend not only upon the associated pseudo-regression coefficient, but also on the entire vector of explanatory variables, the regression coefficients, and the Box-Cox parameter, we give the exogenously-weighted means and standard deviations of these values across the entire sample used to estimate the TCD equation. Note that LOG(DAYS/HOR*31) does not have an associated incremental contribution, since this represents the log(TF) in the derivation.

Table 3B

"GOODNESS-OF-FIT" SUMMARIES, BOX-COX TRANSFORMED TCD MODEL
(exogenously weighted)

Total Compens. Demanded (1=would decline offer, 0=would not)

i.) Individual Prediction Success (individual probability > 0.5):

	Observed		
Predicted	1	0	total
1	1901.13	651.66	2552.79
0	397.42	706.79	1104.21
total	2298.55	1358.45	3657.00

ii.) Aggregate Prediction Success (summed probabilities):

Outcome	Predicted Frequencies	Actual Frequencies
1	2295.27	2298.55
0	1361.73	1358.45

TABLE 4

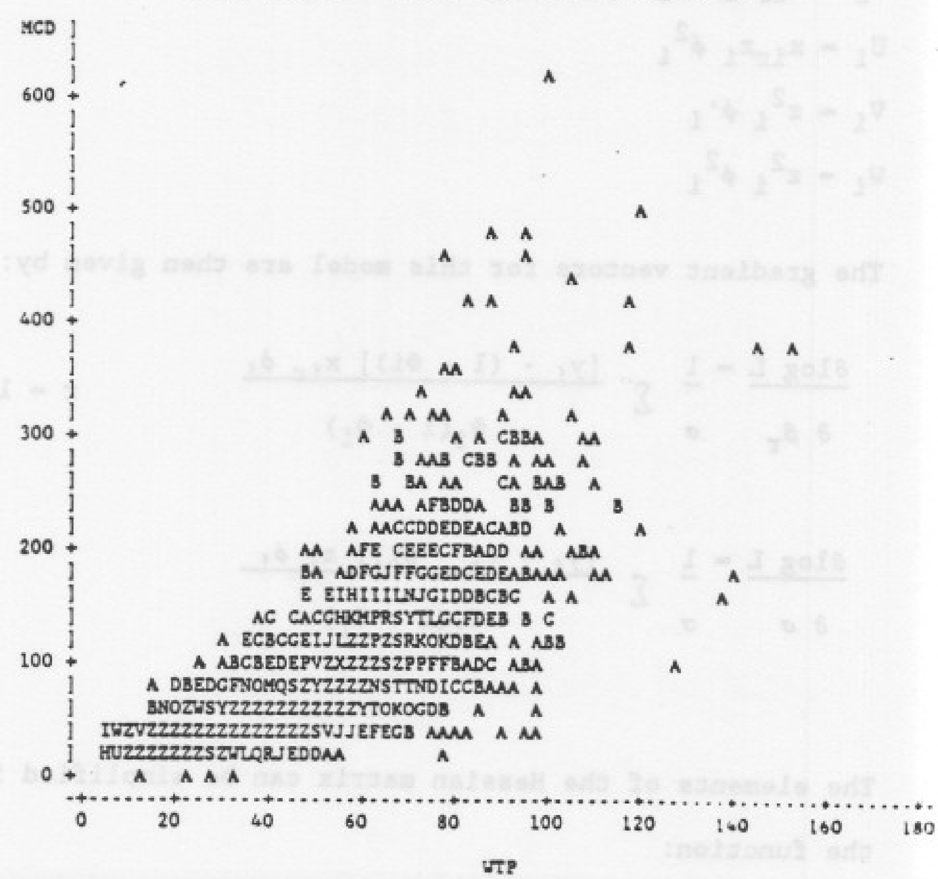
Weighted Regression of Fitted MCD on Fitted WTP

	linear	linear	linear	log-linear	linear no constant
	all	(delete upper 1%)	(delete upper 5%)	all	all
	n = 3657	n = 3593	n = 3377	n = 3657	n = 3657
intercept	-2.233	2.486	8.952	3.061	-
(t-ratio)	(-1.868)	(2.167)	(8.327)	(198.92)	
(t-ratio*)	(-0.8990)	(1.281)	(5.293)	(183.14)	
WTP	1.427	1.291	1.089	0.01936	1.384
(t-ratio)	(54.83)	(50.09)	(42.02)	(57.81)	(122.47)
(t-ratio*)	(19.24)	(21.31)	(19.78)	(41.01)	(49.96)
r(MCD,WTP)	.7428	.7489	.7345		

* using White's heteroskedasticity-corrected covariance matrix (which accommodates unknown form of heteroscedasticity.

Scatter Plot of Fitted MCD Against Fitted WTP
(n = 3657; full sample for TCD model)

PLOT OF MCD*WTP LEGEND: A = 1 OBS, B = 2 OBS, ETC.



APPENDIX I: FORMULAS FOR GRADIENT AND HESSIAN MATRIX ELEMENTS FOR CONTINGENT VALUATION CENSORED DEPENDENT VARIABLE MODEL

This appendix is a summary of the methodology developed in our related paper, Cameron and James [1986]. Using the notation established in the body of the paper, first make the following simplifying abbreviations:

$z_i = (t_i - x_i'\beta)/\sigma$

$\Phi_i = \Phi(z_i)$

$\phi_i = \phi(z_i)$

$\phi'_i = \phi'(z_i) = -z_i\, \phi(z_i)$

$R_i = x_{ir} x_{is}\, \phi'_i$

$S_i = x_{ir} x_{is}\, \phi^2_i$

$T_i = x_{ir} z_i\, \phi'_i$

$U_i = x_{ir} z_i\, \phi^2_i$

$V_i = z^2_i\, \phi'_i$

$W_i = z^2_i\, \phi^2_i$

The gradient vectors for this model are then given by:

$$\frac{\partial \log L}{\partial \beta_r} = \frac{1}{\sigma} \sum \frac{[y_i - (1 - \Phi i)]\, x_{ir}\, \phi_i}{\Phi_i(1 - \Phi_i)} \qquad r = 1,\ldots,p$$

$$\frac{\partial \log L}{\partial \sigma} = \frac{1}{\sigma} \sum \frac{[y_i - (1 - \Phi i)]\, z_i\, \phi_i}{\Phi_i(1 - \Phi_i)}$$

The elements of the Hessian matrix can be simplified if we define the function:

$$G(P,Q) = \sum \left[\frac{y_i(P_i[\Phi_i - 1] - Q_i)}{[\Phi_i - 1]^2} + \frac{(1 - y_i)(P_i\Phi_i - Q_i)}{\Phi_i^2} \right]$$

Then we can specify:

$$\frac{\partial^2 \log L}{\partial \beta_r \partial \beta_s} = \frac{1}{\sigma} G(R,S) \qquad r,s = 1,\ldots,p$$

$$\frac{\partial^2 \log L}{\partial \beta_r \sigma} = \frac{-1}{\sigma} \frac{\partial \log L}{\partial \beta_r} + \frac{1}{\sigma^2} G(T,U) \qquad r = 1,\ldots,p$$

$$\frac{\partial^2 \log L}{\partial \sigma^2} = \frac{-1}{\sigma} \frac{\partial \log L}{\partial \sigma} + \frac{1}{\sigma^2} G(V,W)$$

Use of these analytic derivatives, instead of numerical approximations to the required derivatives, can reduce computational costs considerably. These derivative formulas can also be used in conjunction with point estimates computed from ordinary probit models (and the data) to compute the asymptotic standard errors for the true coefficients from our maximum likelihood model.

APPENDIX II: DATA AND DATA LIMITATIONS

Sportfishing activities in B.C. tidal waters range from angling for trophy chinook salmon in remote locations to wading in with a net to catch crabs. The majority of anglers target on chinook (spring, king) and coho (silver) salmon which are available throughout the coastal area. However, species other than salmon, such as ling cod and rock cod, are important and make up about 40 percent of the recreational catch of finfish.

Between 75 and 80 percent of the sportfishing effort occurs in the protected waters between Vancouver Island and the mainland. About 94% of this effort is boat-based with the rest being from shore, piers or by SCUBA diving. Because of the preponderance of boat-based effort concentrated in certain locations, data for this study were obtained by personal interviews conducted with boating parties who had just landed at ramps or marinas. Four locations were selected for interviews: Victoria, Campbell River, Sechelt and Port Alberni. In the Port Alberni area, two sites were selected for interviewing. Three or four sites were selected in the three other areas.

The survey started in the second week of July, 1984. In the Victoria region, interviews continued until the first days of December. In other areas, the survey was terminated in mid-October due to lack of fishing effort (too few potential respondents to justify maintenance of the survey staff). Over the entire course of the survey, 4161 usable responses were collected. Approximately one-half of the interviews occurred in the Port

Alberni area where there are very few potential landing sites resulting in a high volume of traffic through the two sites chosen as interview locations.

One adult from each boating party was selected at random for interviewing. The questionnaire used in the interview was developed by one of the authors, (James) and is reproduced in Appendix III. It consists of two parts. The first part asks for information about the just-completed sport fishing trip (number of people in the party, hours fished, fish kept and released). These questions pertain to the entire fishing party. The second part of the questionnaire solicits individual responses of the person being interviewed to determine individual WTP and CD for a day of sportfishing as well as angler characteristics, and a subjective assessment of the degree of enjoyment the individual would assign to the fishing experience.

The question which solicits a CD response was worded to cover the hypothetical loss of fishing opportunities between the time of the interview and the end of the next month. The interviewer had to multiply the angler's projected days fishing in that time by the amount pre-written on the questionnaire and then enquire whether that total would be acceptable compensation for loss of that fishing time. The above time period was selected as a compromise between asking just one or two days, where the substitute is simply to fish the next day instead, and a longer period such as a year, over which respondents are unlikely to be able to say how many days they would fish.

The WTP question was asked in terms of an increase in associated costs in order to attempt to avoid "vehicle bias" in the form of fears that the federal government might actually be planning to charge them that much. In pilot testing, a similar question in a 1983 postcard questionnaire clearly implied to many respondents that a daily fee was being considered. Respondents tended to cross out the question or write "no way" all over it. If queried about the dollar amounts being used in these questions, interviewers could indicate that different amounts were being asked of each respondent, thereby allaying such fears to a certain extent.

In attempting to infer individuals' valuations of the sportfishing resource from the responses elicited by the survey, we are faced with a problem in the class of "censored dependent variable models." Three shortcomings of the data must be acknowledged at the outset. First, although we will assume some underlying well-behaved symmetric distribution of true values (conditional on the characteristics of the angler and the fishing experience), we cannot avoid the possibility that reported values may differ from true values. For example, anglers probably have an incentive to overstate their true CD. WTP may be either over- or under-stated depending on how the respondent perceives that the information will be used. If he expects usage fees to be based on his response, he will understate. If he expects resource enhancement to reflect his valuation, he will overstate. Unfortunately, it is impossible to evaluate the seriousness of the discrepancy between reported and actual values. However, working in our favor is the spontaneity of responses in a personal interview. A mail questionnaire would have provided a greater opportunity for strategic responses. We hope that the personal interviews used in this case have elicited instead the respondents' immediate reactions, since this method minimizes the amount of time a respondent has to weigh all possible implications of a given answer.

The second feature of the data set is that we do not observe even this "reported valuation." Instead, we know only that the respondent would or would not accept a certain number of dollars to forgo fishing (or that he would or would not continue to fish if daily expenses were a specific amount higher). It is understood that asking a respondent himself to assign a specific dollar valuation for either CD or WTP can be fraught with bias problems. (See Thayer [1981].)

One misfortune in the data is that the pilot survey indicated the impossibility of gathering accurate income data. Many respondents in the pilot survey became downright hostile when questioned about their income levels. Since 33% of the responses were by anglers who had been interviewed previously, there was also substantial resistance to questions which did not pertain to the current fishing trip (i.e. personal data).

SPORT FISHING ECONOMIC SURVEY   № 3901

Landing Site: ____/____ Statistical Area: ______

Interviewer: ____/____ Date: __/__/__ (YR MO DAY) TIME (INT) ___:___ AM PM

M T W T F S S

PARTY

1. Total Number of Individuals in Party: .... [ ]
2. Time of Landing: ___:___ AM PM Time Block: .... [ ]
3. Was your party sport fishing on this trip? .... No [ ] Yes [ ]
4. Guided: .... No [ ] Yes [ ]
5. Rental Boat: .... No [ ] Yes [ ]
6. Length of Boat Trip: .... HRS [ ]
7. Times Lines were in the water: (EXCLUDE time not fishing)

[ ] 1) Before 7:00	[ ] 5) 10:00 - 10:59	[ ] 9) 2:00 - 2:59	[ ] 13) 6:00 - 6:59
[ ] 2) 7:00 - 7:59	[ ] 6) 11:00 - 11:59	[ ] 10) 3:00 - 3:59	[ ] 14) 7:00 - 7:59
[ ] 3) 8:00 - 8:59	[ ] 7) 12:00 - 12:59	[ ] 11) 4:00 - 4:59	[ ] 15) 8:00 - 8:59
[ ] 4) 9:00 - 9:59	[ ] 8) 1:00 - 1:59	[ ] 12) 5:00 - 5:59	[ ] 16) 9:00 - Plus

8. CATCH SUMMARY

1st SUB AREA	KEPT	RELEASED	TIME
2nd SUB AREA	KEPT	RELEASED	TIME
3rd SUB AREA	KEPT	RELEASED	TIME
	TOTAL KEPT	TOTAL RELEASED	TOTAL TIME

MARKED: [ ] UNMARKED: [ ]

* COHO AND CHINOOK ONLY

9. Did you personally fish today? .... No [ ] Yes [ ]
10. What is your residence? .... BC [ ] Rest of Canada [ ] Other [ ]
11. Largest fish caught by you? .... LB [ ] Species [ ] None [ ]
12. How many days did you fish in BC tidal waters in 1983? .... DAYS [ ]
13. How many days do you plan to go fishing between now and the end of next month ? .... DAYS [ ]
14. Suppose you were offered ____ (days) x ____ = ____ dollars to give up fishing in tidal waters until the end of next month. Would you accept the offer? .... No [ ] Yes [ ]
15. How much did you spend on your fishing trip today? .... (Include costs such as bait, gasoline, boat rentals. Do not include equipment costing more than $100.) $ ______
16. Now imagine that the cost of fishing in BC tidal waters increased. If the cost of your fishing trip had been ________ dollars higher today, would you still have gone fishing? .... No [ ] Yes [ ]
17. How enjoyable was today's fishing trip? 1. very 2. reasonably 3. somewhat 4. not at all .... [ ]
18. Have you been interviewed on this economic survey before? .... No [ ] Yes [ ]

APPENDIX IV: BIVARIATE MODEL FOR JOINT ESTIMATION OF BOTH WILLINGNESS-TO-PAY AND TOTAL COMPENSATION DEMANDED

A. Theoretical Framework

A more general model is possible if we relax the implicit assumption of zero correlation between the error terms in the WTP model and the TCD model and make this error correlation a parameter to be estimated. It is entirely logical that these two measures of valuation should be influenced by common unobserved factors affecting each individual. Separate estimation of the the two models ignores this possibility. If the data are sufficiently "rich", then, it should be possible to infer simultaneously both the dispersion of each true valuation around the fitted values and any correlation in the error terms. Explicit treatment of this potential correlation could produce efficiency gains in the estimation process. Let Y_c be the true TCD and let Y_w be the true WTP. Each individual is randomly assigned a threshold threshold value of t_c and t_w and we observe the discrete choices y_c and y_w (as either 1 or zero). Figure IV.1 depicts the model in this situation. For two-dimensional intelligibility, the figure shows the conditional joint distribution (hypothetical level curves) of the two dependent variables, but only for a single hypothetical value of a common explanatory variable, x. Again, for clarity, we only attempt to display simple regression diagrammatically, although the mathematical model is easily adapted to accommodate multiple regression, and even different sets of explanatory variables for each dependent variable involved. When the model is actually estimated, the dependent variables will be subjected to the Box-Cox transformation.

Analogous to the univariate case, we see from this example that:

$$\Pr(y_w = 1 \ \cap \ y_c = 1)$$
$$= \Pr(-u_{wi} < x_{wi}'\beta_w - t_w \cap -u_{ci} < x_{ci}'\beta_c - t_c)$$
$$= \Pr(u_{wi} > t_w - x_{wi}'\beta_w \cap u_{ci} > t_c - x_{ci}'\beta_c)$$

If we assume that u_{wi} and u_{ci} are jointly normally distributed, we can transform these conditional error terms to bivariate standard normal random variables by dividing by their respective standard deviations, σ_w and σ_c:

$$\Pr(y_w = 1 \ \cap \ y_c = 1)$$
$$= \Pr([z_{wi}>(t_w-x_{wi}'\beta_w)/\sigma_w] \cap [z_{ci}>(t_c-x_{ci}'\beta_c)/\sigma_c])$$

This joint probability is merely the volume under what might be called quadrant I for joint standard normally distributed random variables (for quadrants defined by the t_w and t_c values). For a given correlation between z_{wi} and z_{ci}, there exist easily-utilized subroutines (IMSL MDBNOR) to evaluate this probability, as well as the probabilities for the other three quadrants.

B. Empirical Results for the Bivariate Model

This model recognizes that WTP and TCD are determined by the same decision-making agent: the individual angler. As mentioned in the text, the argument is often made that the two constructs should be measuring the same underlying quantity. It is important to allow for correlations in the error terms associated with the two measures, since the same unobservable factors will be affecting the respondent as both crucial questions are addressed. What we will next undertake is an estimation process similar in spirit to the familiar "seemingly unrelated regressions" model. No endogenous variables appear on the right hand side of either of the separate models, but the potential for correlation in the error terms should be entertained.

We wish to take as a point of departure the ultimate specifications of the separate WTP and TCD models. We will "cheat" a little, however, by using only the subsample of respondents for which the TCD model was estimated (since the programming task with different numbers of observations is more difficult). Unfortunately, however, this means that a total of 47 unknown parameters just be estimated by nonlinear optimization. In addition, the likelihood function for the joint model is sufficiently complex that analytical derivatives are more or less prohibitively difficult. Estimation of the full joint model is therefore incredibly time- and CPU-intensive. Consequently, we have opted to take advantage of the fact that the regression point estimates from the individual models (as in Seemingly Unrelated Regression) are consistent estimates for the regression parameters of the joint model (although we must use a slightly different set of WTP parameters to reflect the smaller sample). We undertake an optimization with respect to σ_w, σ_c and ρ, conditional upon the other 44 parameters from the separate models. We find a fitted value for ρ of only 0.1887; the fitted error standard deviation for the WTP equation decreases from 5.092 to 5.066; the fitted error standard deviation for the TCD equation decreases from 2.473 to 2.450. The usual individual and aggregate goodness-of-fit measures (this time for the four-alternative model) are provided in the Table IV.1.

Since the correlation between the error terms in the two equations seems to be very small, we are confident that there is little loss in efficiency due to separate estimation of the two models. It is important to note, however, that in other applications (without the wealth of explanatory variables we have here) it is highly possible that the error terms will be quite strongly correlated. There may be considerable gains in efficiency (i.e. dramatic improvements in individual asymptotic t-statistics) when the model is estimated jointly. Joint estimation will also be more feasible in these cases, since the parameter space will likely also be much smaller. For this example, however, the errors are only slightly positively correlated, indicating that some unknown factor will tend (slightly) to cause WTP to exceed the model's fitted value at the same time as it causes TCD to be larger than the model would suggest (and vice versa). Omitted factors which might lead to a positive correlation between error terms could be anything from income, to an angler's degree of obsession with sport-fishing to a bad case of indigestion.

Table IV.1

"GOODNESS-OF-FIT" SUMMARIES FOR JOINTLY ESTIMATED MODEL

KEY: 1 = would be willing to pay extra amount, would decline offered compensation
2 = would be unwilling to pay extra amount, would decline offered compensation
3 = would be unwilling to pay extra amount, would accept offered compensation
4 = would be willing to pay extra amount, would accept offered compensation

a.) Individual Prediction Success (predicted = highest probability)

	Observed				
Predicted	1	2	3	4	Total*
1	1486.99	248.46	147.85	504.65	2369.95
2	45.45	157.70	52.39	14.65	270.19
3	26.76	87.18	228.26	47.64	389.85
4	230.45	33.57	57.59	305.41	627.02
Total*	1771.65	526.90	486.10	872.35	3657.00

b.) Aggregate Prediction Success (summed probabilities)

Outcome	Predicted Frequencies	Actual Frequencies
1	1786.11	1771.65
2	511.72	526.90
3	480.94	486.10
4	878.23	872.35

* totals may not agree, due to rounding.

FOOTNOTES

[1] A variety of experimental studies have supported the superiority of contingent valuation methods over other approaches, including the travel-cost method, "costs and prices of substitutes" methods, and "property value" methods. (See comparison studies by Knetsch and Davis [1966], Desvouges, Smith and McGivney [1982], Sellar, Stoll and Chavas [1985], Thayer [1981] and studies cited in Schulze, D'Arge, and Brookshire [1981] plus Brookshire, Thayer, Schulze, and d'Arge [1982].

[2] They cite several approaches ("dockside price," "average expenditure," and "average consumer surplus") and describe the shortcomings of each.

[3] Note that we allow both the monetized value of time spent fishing and of time in other activities to differ from the wage rate. This reflects empirical results in the "value of travel time" literature which suggest, for example, that the value of time spent commuting is less than the hourly wage. A more restrictive model could of course be specified.

[4] Unfortunately, no questions regarding employment or working hours were posed, and (in order to ensure even a reasonable proportion of completed interviews) it was necessary to drop the income question on the final survey. This precludes even an approximate assignment of values for each individual's Y, w, w_F, w_N, T_w, or L variables. In any event, it would be extremely difficult to elicit accurate effective values of many of these

variables under any circumstances. It is also not possible to accurately model consumption of the composite commodity, Z_N or likewise to assign any meaningful value to the quantities or prices of the market inputs to its production (i.e. X_N and P_N). Consequently, we focus upon the relationship between T_F, P_F, R_F and Q_F.

[5] One further shortcoming of the dataset is that we are unable to determine the identity of individual respondents, although for a substantial number of responses, the individual has been interviewed before. Thus while the theoretical development addresses the individual angler's optimization process, the data pertain to individual fishing days.

[6] The data on number of days of sportfishing demanded are thus somewhat awkward. The time horizon facing each survey respondent varies in length. The number of days "between now and the end of next month" can vary from 30 to 62, depending on the day of the month on which the questions were asked. Fortunately, it is possible to determine the length of this time horizon. We then make the admittedly heroic assumption that planned fishing days are distributed uniformly over the time horizon of each individual, and conform the relevant quantities to a common 31-day month. However, this ignores any cyclic variation in the demand for fishing days, a problem which is compounded by the fact that the data are only for the months of July through early December. It would be preferable to know each angler's demand for fishing days for an entire cycle (either a year, or the relevant "fishing

season"). Due to the timing of vacations, we may accidentally have captured the entire span of a respondent's specific fishing vacation, or we may have encountered the respondent on the last day of an intensive fishing vacation, when no further fishing days are anticipated. To interpret, as we do here, an individual's monthly planned fishing days between the survey date and the end of the next month as their annual average monthly demand for fishing days is admitted a rough approximation, which will unavoidably introduce a degree of measurement error into the coefficient estimates.

[7] A similar dilemma is faced by researchers addressing the value of human life using the magnitudes of wage premia in hazardous jobs. Myopia, or at least large discount rates applied to events in the distant future, can seriously affect the compensation required for imminent hazards as opposed to hazards which will not have health manifestations for many years.

[8] Maximum likelihood logit regression models assume a logistic distribution for the underlying unobservable dependent variable, but these models set the variance of this distribution arbitrarily to one, since the dispersion cannot be measured explicitly. We could, of course, adopt the two-parameter logistic distribution for our new model. We might try this in subsequent analyses.

[9] Ordinary probit analysis can of course be employed to produce starting values for the estimation process. The expression $(t_i - x_i'\beta)/\sigma$ can be rewritten as the inner product:

$- (t, x') (-1/\sigma, \beta/\sigma) = -x_a'\beta_a$

and the augmented vectors of variables and coefficients may be treated as one would treat the explanatory variables and coefficients in an ordinary probit estimation. The point estimates of the individual parameters should be identical by either technique, but it is accurate standard error estimates we seek. If earlier authors had recognized this relationship, they would have found numerical integration of the area above a logit curve unnecessary. (See, for example, Sellar, Chavas, and Stoll, [1986].)

[10] While the required derivatives can often be evaluated numerically, these analytic formulas can substantially reduce computational costs.

[11] We acknowledge the difficulties inherent in the Box-Cox transformation which arise from the fact that the transformed variable will be bounded either from above or below by $(-1/\lambda)$, depending upon the sign of λ. As described in Amemiya [1985, 250], this limitation means that true distribution of errors in the transformed model cannot be normal. This violates a fundamental condition for the validity of the maximum likelihood estimates. However, we will proceed for the time being (as has commonly been done) without undertaking specific corrections for this deficiency.

[12] Again, note that no correction has yet been undertaken to compensate for the fact that when $\lambda = 0.5364$, the distribution of

the Box-Cox transformed implicit dependent variable will be bounded from below at $-1/\lambda$ (approximately -1.864). If we adopt the notation that $\theta = \{ \beta, \sigma, \lambda \}$, it will furthermore be the case that the covariance matrix for $\sqrt{n}(\hat{\theta} - \theta)$ is not equal to the its usual formula: $- \lim n[E\, \partial^2 \log L/\partial\theta\partial\theta']^{-1}$. Instead, as Amemiya [1985, 251] indicates, the asymptotic covariance matrix will be given by:

$$V(\theta) = \lim n \left[E \frac{\partial^2 \log L}{\partial\theta\partial\theta'} \right]^{-1} E \frac{\partial \log L}{\partial\theta} \frac{\partial \log L}{\partial\theta'} \left[E \frac{\partial^2 \log L}{\partial\theta\partial\theta'} \right]^{-1}$$

We plan subsequently to compute revised estimates of the asymptotic t-test statistics, using the sample analog of this formula. Meanwhile, statistical hypotheses concerning the estimated parameters should be interpreted with caution.

[13] Estimation of the censored dependent variable model described above was accomplished using the Fortran-based non-linear optimization subroutine package GQOPT. While various econometrics computer software packages can now perform conventional probit and logit estimations, the more-complex techniques explored in this study require a more general program.

[14] Since the sample is not exactly representative of the population, we must employ exogenously determined weights with this likelihood function. These weights are based on a 60-cell crosstabulation (RESIDENCE by SITE by MONTH) of both the relevant population and the sample. Fishing "effort" (in total days) and

salmonid catch rates are available. We have chosen to weight our sample observations according to the proportion of total annual effort in each of these 60 cells. All results are reported for the weighted sample.

[15] FEXP is actually the inner product of both the prices and the quantities of these market goods. If either prices or quantities are approximately constant across observations, the explanatory power could be attributed to the varying component. However, without further evidence, no such assumption can reliably be made.

[16] Another possibility, of course, is that only very keen anglers go out on unpleasant days.

[17] Early in the estimation phase, a logit model was estimated with EVERY as the dependent variable. As expected, the probability that a particular fisherman enjoys the current fishing trip "very much" can also be predicted quite well by the fishing trip's characteristics. However, perfect collinearity is not a concern. Different sets of variables explain enjoyment and valuation.

[18] Because we are interested in the possibility of systematic differences in the determinants of WTP in the four different major areas, we have also estimated separate models for each area. Separate models are preferred over a complete set of slope and intercept dummies due to the fact that computational requirements increase with the square of the number of estimated parameters. These estimates are available from the authors.

[19] It is not clearcut how h should affect TCD. At least two possibilities exist. First, if the same number of planned fishing days is spread evenly over a longer time horizon, we might expect the greater discounting of fishing days further removed into the future to decrease the total CD. Unfortunately, however, we do not know the distribution of the number of planned fishing days over the time horizon. We cannot distinguish between, for example, ten fishing days at the beginning of a 40-day time horizon and ten fishing days, one every fourth day, over a 40-day time horizon.

A second possibility concerns the individual's perceptions about substitutes for the planned fishing days to be forgone. If the specific time horizon captures every day this year that the individual will have an opportunity to fish, the total CD will be higher than if the individual anticipates opportunities to take up fishing again immediately after the time horizon has passed. The only information we have which might allow us to control for this possibility is the data on the number of days each respondent fished in 1983. For example, if the planned number of days as a proportion of the time horizon in question exceeds a certain ratio when compared to the proportion of days fished in 1983, we may be able to assume one or the other of these substitution opportunities between fishing during the time horizon and fishing after that horizon. Still, any such partitioning of the sample would be completely *ad hoc*.

[20] The first specification to be explored was quadratic in T_F, with additional cross-product terms in the Q_F variables. However, this specification yielded an implausibly large number of negative fitted values for MCD. It does not seem intuitively reasonable, at least *ex ante*, that anglers would plan to consume fishing days beyond the point marginal utility becomes negative (so that marginal valuation also goes negative). While it may be possible *ex poste* that anglers will realize that they have committed to consuming fishing days into the region of negative marginal utility, the current data are for planned future fishing days. It would seem appropriate to employ a functional form where TCD is constrained to be monotonically increasing over the range of the data.

[21] The sample contains 508 respondents who plan no fishing days between the interview day and the end of the following month. These respondents do have a non-zero *per-day* compensation offer recorded, but the interpretation of their response to the question about willingness to give up zero fishing days is somewhat confusing. These responses are deleted from the sample, so that the following observations pertain only to fishermen who report non-zero planned fishing days.

[22] We have examined the weighted distribution of fitted WTP values for the subset of the sample for which planned fishing days to the end of next month were zero. The mean is slightly higher than that of the entire population (at $50.85), and the standard deviation is $25.84. The distribution is highly symmetric,

however, exhibiting only a slight upward skewness in the unweighted fitted values.

[23] It is extremely unfortunate at this point that we do not have information on the respondents' incomes. If it is true that the measures should be identical "except for wealth effects", then we could possibly include income as a second explanatory variable in the regression of MCD on WTP. The sign of this coefficient would help up quantify the extent of distortion from this source.

[24] To a lesser extent, these models could be adapted to assess the effects of policies which influence the distributions of weights among each species of fish. This task would be easier, however, if the questionnaire had elicited the weights of all fish caught, not just the largest. As is, the simulations would have to accommodate any variation in the probability that the largest fish belonged to each species, as well as the influence of the policy upon the extreme values in a "sample" consisting of the number of fish caught of each type. With the current dataset, the assumptions required would probably be too heroic to generate reliable predictions. Consequently, we do not explore this class of policies any further.

[25] While the issues mentioned above cannot be addressed using the present survey, preparations are currently being made to mount an extensive telephone survey of randomly selected households. This survey will interview non-fishing individuals as well as active

fishermen and will be designed to elicit information on option and existence demands.