ECONOMIC VALUE OF SALMON ANGLING: 
ESTIMATES OF WILLINGNESS TO PAY 
FROM HEDONIC PRICE FUNCTIONS*

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Introduction

There has been growing concern over the last several years that our fisheries resources have not been effectively managed because of the emphasis on physical rather than economic relationships. The reliance on biological models have not been effectively managed because of the emphasis on physical rather than economic relationships. The reliance on biological models arose from the expectation that maintenance of "the stock" was a sufficient condition for a healthy fishery. The overall demand-supply nexus was given short shrift as were the substitution possibilities on both the demand and production side. Traditional biological models used for planning purposes have increasingly given way to bio-economic models [3]. One of the reasons for this shift has been the need to model the interrelationship between the quantity and distribution of benefits resulting from larger (or smaller) stocks of certain fish species and the various policies of both the federal and provincial governments [2]. Boat subsidies, quotas, price supports, and unem-

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ployment insurance provision are all examples of government programs influencing choices.

The Atlantic salmon fishery like other east and west coast fisheries has both benefited and suffered from the policies of government. The principal economic reason for government involvement is the common property resource nature of fish; fishermen overfish the existing stock because of the lack of a mechanism by which they could appropriate the benefits if they left some of their catch. As Ferris and Plourde [2] point out, government policy has created uncertainty and therefore increased costs, but a lack of a policy would perhaps have been worse. Certainly much of the problem of developing effective strategies in dealing with the fisheries is the incomplete understanding of the linkages within the industry and general inability to estimate the value and distribution of the benefits of the alternative strategies.

Economists have argued (see Ferris and Plourde [2], for example) that a superior mechanism by which to meet some of these difficulties is to create a scheme to internalize externalities while maintaining the right to set the catch quotas for a certain stock. One option is to auction off fishing rights to select parts of an area. This auction system establishes property rights (albeit for only the lease period) to successful bidders. Through this auction the government can protect the stocks, reap some benefits from the fishery and collect the resource rents. This approach has been criticized because of expected high policing costs and problems of fish migrating, particularly across international boundaries.

The lease auctions provide "market information" from which one can evaluate fishery strategies, upset or reservation prices, and crowding effects. The economic value of a resource determines for the most part its optimal exploitation rate and thus optimal stock. Commercial fisheries markets provide the requisite economic information, but the sport fishery rarely does. It is therefore normally difficult to develop sound strategies in dealing with the sport fishery with respect to allowable catches, season length, or stocking because the "economic" value is not known; auctions indirectly may provide such information. Further, the upset or reserve lease price can also be evaluated in terms of the level and perhaps the amount by which it should vary over leases. Finally, the bid information from leases can be used to evaluate and develop strategies for the "public" fishery.

Salmon were for many years a mainstay of the eastern provinces inshore and recreational fisheries. In the 1960s overfishing of Atlantic salmon, to which new fisheries off Greenland contributed significantly, led to restrictions on Atlantic salmon fishing in Canada. Commercial fishing was banned in all of New Brunswick in 1972 but continued in some parts of Newfoundland and off Greenland. At the same time the Government of New Brunswick continued its practice (started in the 1880s) of auctioning off leases to various stretches of two prime salmon rivers for sport fishing. They also permit some limited "public" sport fishing which tends to be crowded and have a low success rate.

This paper utilizes an extension of hedonic price functions to examine the value of leases auctioned by the New Brunswick government in 1979, and determines how bids varied with lease characteristics. We then use this information to estimate the "value" of salmon. The first section contains a discussion of the theoretical considerations in measuring lease values; empirical estimates are contained in the second section, while conclusions are presented in the final section.

Theoretical Considerations

The auctioning of property rights to the allowable quota of salmon does not represent the auction of a homogeneous good. Rather, the bidding depends on the characteristics of the leases such as location, onsite camps, salmon abundance, potential rod-days, and so on. In order to estimate the values of the leases, these differing characteristics must be netted out, as it were, in order to obtain a pure measure of the value of the fish stock.

Fish stocks have a public good nature, and there exists no explicit market in which these stocks can be evaluated. This problem is very much like that associated with attempts to estimate the demand for housing, which is also a joint multi-attribute good [10]. The approach taken in these situations is to utilize hedonic demand theory in order to determine the value or willingness to pay for a characteristic or set of characteristics.

There has been an extensive debate in the literature as to the validity of this technique of using the [winning] bid prices for bundles of characteristics to determine the marginal evaluation of a particular characteristic. It has been argued, for example, that it is inappropriate to use marginal prices from an hedonic estimation to estimate value or willingness to pay because the regression coefficient reflects the market equilibrating price in a demand-supply situation. Polinsky and Shavell [7] demonstrated that such estimates are estimates of willingness to pay only if rents extract all surpluses. This will be true only under a restrictive set of conditions. Recently McMillan, Reid and Gillen [4] demonstrated that it is possible to relax the restrictive assumptions noted

1This point is discussed by Rosen [8].
by Polinsky and Shavell and use the hedonic technique to estimate willingness to pay. The stimulus to this contribution was the general problem of limited information typically available when faced with issues of this sort. Ideally one would like to estimate the parameters of the underlying utility function and association demand equations. This, however, requires additional information. Wheaton’s work [9] illustrates the extent of the data requirements when estimating housing bid functions.

A fishing lease represents a tied bundle of characteristics including location, allowable rod-days, and salmon abundance. Let all characteristics be represented by \( c_i \) and salmon abundance by \( s \). In having a winning bid for a lease the lessee acquires the tied characteristics bundle \( L \) at a lease price of \( V \). With different leases having different bundles of characteristics, the bidding process establishes a price (hedonic) function:

\[
V = V(L) = \phi (c_1, c_2, c_3, ..., c_n, s)
\]

In an attempt to estimate the values of Crown leases, and particularly salmon stocks, we regressed lease bids against lease characteristics. Information was available for each lease on the price of the lease, the river mileage, the maximum number of rods per day, the maximum number of rod-days per season, the actual number of rod-days, and the total number of salmon (including grilse) caught. The catch and effort data were available over three seasons (1978-80) and average values of these variables were used in the model.

In addition to these variables, dummy variables were used to account for four other phenomena. First, a number of leases are held by corporations. Since corporations would only have to outbid private groups or individuals by a nominal amount to capture a lease at the auction, the coefficient on this dummy should not be interpreted as the premium that corporations are prepared to pay unless it turns out to have a nominal value. It is likely, however, that if corporations use their leases to entertain individuals who are important to them, they would seek leases which have other characteristics or quality for which information is not available. This dummy should be correspondingly interpreted in this manner. The leases included in this category were those for which the lessee was listed as a corporation.

A second dummy was included to account for the existence of competitive bidding in a limited number of leases, since in many cases leases were retained by the previous lessees without competing bids. The value and significance of the coefficient will indicate whether the presence of competitive bidding had an impact on the auction price or the upset price was simply set too low for these leases. Dummies were used including and excluding lease 11, and the dummy excluding lease 11 performed substantially better, therefore it was chosen.

A third dummy was introduced to indicate the location of the lease. Leases on the Restigouche drainage will be distinguished from the other leases (referred to as Miramichi leases, although they include the Cains and Tabusintac leases) by means of a dummy variable.

The fourth dummy was used to determine the impact of the fact that leases 13 and 20 are primarily trout leases with a late season salmon run.

Lease 2 was omitted from the study because over the period 1978-1980 no salmon were caught. The reason for leasing is primarily because the lessee also holds private land contiguous with the lease.

Table 1 sets out the variables used in the empirical estimation.

Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V )</td>
<td>auction price of the lease (1979)</td>
</tr>
<tr>
<td>( RD )</td>
<td>maximum number of rods per day</td>
</tr>
<tr>
<td>( CPE )</td>
<td>average catch per rod-day (1978-80)</td>
</tr>
<tr>
<td>( DR )</td>
<td>a 0-1 dummy variable equal to one for the Restigouche leases</td>
</tr>
<tr>
<td>( DB )</td>
<td>a 0-1 dummy variable equal to one for competitive bidding</td>
</tr>
<tr>
<td>( DC )</td>
<td>a 0-1 dummy variable equal to one for corporate lessees</td>
</tr>
<tr>
<td>( DT )</td>
<td>a 0-1 dummy variable equal to one for mixed trout/salmon lease</td>
</tr>
</tbody>
</table>

One of the problems faced in this type of model is that many of the characteristics may be closely related, thus introducing the problem of multicollinearity. The effect of multicollinearity is to make it difficult to isolate the impact of variables separately. For this reason, not all seemingly relevant variables could be included in one equation.

Several variables were found to have no significant impact on the values of the leases. The mileage of the lease was not significant, because either this was not a variable which reflected any important characteristic or it could represent both positive and negative effects.

Information indicated that the "outstanding examples of competitive bidding were for leases numbers 4 and 14, with lease number 11 also receiving competitive bids".
negative characteristics. The second variable that was not significant was the maximum number of rod-days per season. This did not function as a constraint on any of the leases and was not, therefore, a measure of any effective characteristic.

The model was estimated in a logarithmic form with a reciprocal transformation on the average catch per rod day:

\[
\ln V = a_0 + \sum_{p=1}^{n} a_1 \ln c_i + \sum_{p=1}^{n} a_j d_j + b/CPE + u
\]

where \(d_j\) refers to the characteristics treated as dummy variables, and \(a_0, a_1, a_j, b\) are parameters to be estimated.

Since leases on the Restigouche are priced higher on average, equation (2) was also estimated using a "slope dummy" to test whether particular characteristics are valued differently on the two river systems. Since we are focusing on the marginal willingness to pay for salmon, a new variable was added, \(DR/CPE\), which is zero for the Miramichi leases. The coefficient for the Restigouche for the variable \(1/CPE\) is the sum of the coefficients on \(1/CPE\) and \(DR/CPE\). Similarly, the variable \(DR^* \ln RD\) was used to test for a difference in the value of an extra rod per day. The ordinary least squares estimates of (2) are reported in Table 2.

It can be seen that the addition of the slope dummies improves the fit in (2.2) and (2.3), compared to (2.1). In each equation, the dummy variables representing competitive bidding, corporate ownership, and the trout leases are important explanatory variables. Over the three equations, the value of the coefficient on \(DB\) ranges from 0.939 to 1.007 and in each case is highly significant. The interpretation is that competitive bidding on a lease will increase the auction price by 94 percent to 101 percent. In the case of lease 4, the auction price of $15,000 was nearly double the upset price ($7,650).

Other considerations given, it appears across the three equations that corporate bidders pay about 45 percent more than non-corporate bidders (coefficients range from 0.423 to 0.487). This should not be interpreted in the same way, however, as the competitive bidding dummy. For all characteristics held constant in the equation, corporations pay about 45 percent more, but it is suspected that there are other attributes of the leases that are not considered (e.g., aesthetics) which warrants their higher price, or it could be a risk premium if the auction is sealed.

Equation (2.3) shows that an increase in the maximum number of rods per day is more highly valued on the Restigouche than on the Miramichi. The results indicate that a 10 percent increase in the allowable rods per day would bring a 9.8 percent increase in lease prices on the Restigouche and a 7.6 percent increase on the Miramichi. In money terms, one additional rod per day is valued at $1,850 on the Restigouche and $650 on the Miramichi. This substantial difference arises for two reasons. First, the average allowable rods per day is greater on the Miramichi, with diminishing marginal utility suggesting a reduced willingness to pay for additional rod-days. Second, the average catch per rod-day is lower on the Miramichi, and consequently an extra rod-day is worth less.

Table 2
RESULTS OF ESTIMATED PRICE EQUATIONS
DEPENDENT VARIABLE: \(\ln V\)

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>2.1*</th>
<th>2.2</th>
<th>2.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>7.795</td>
<td>7.397</td>
<td>7.558</td>
</tr>
<tr>
<td></td>
<td>(21.56)</td>
<td>(22.29)</td>
<td>(23.81)</td>
</tr>
<tr>
<td>(\ln RD)</td>
<td>0.816</td>
<td>0.981</td>
<td>0.763</td>
</tr>
<tr>
<td></td>
<td>(4.77)</td>
<td>(6.40)</td>
<td>(4.86)</td>
</tr>
<tr>
<td>(DR^* \ln RD)</td>
<td>-</td>
<td>-</td>
<td>0.215</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2.54)</td>
</tr>
<tr>
<td>(DB)</td>
<td>0.939</td>
<td>0.970</td>
<td>1.007</td>
</tr>
<tr>
<td></td>
<td>(3.83)</td>
<td>(4.81)</td>
<td>(3.27)</td>
</tr>
<tr>
<td>(DC)</td>
<td>0.487</td>
<td>0.446</td>
<td>0.423</td>
</tr>
<tr>
<td></td>
<td>(3.23)</td>
<td>(3.57)</td>
<td>(3.28)</td>
</tr>
<tr>
<td>(DT)</td>
<td>-1.169</td>
<td>-1.053</td>
<td>-0.954</td>
</tr>
<tr>
<td></td>
<td>(-4.42)</td>
<td>(-4.79)</td>
<td>(-4.02)</td>
</tr>
<tr>
<td>(1/CPE)</td>
<td>-0.224</td>
<td>-0.245</td>
<td>-0.170</td>
</tr>
<tr>
<td></td>
<td>(-3.47)</td>
<td>(4.56)</td>
<td>(2.93)</td>
</tr>
<tr>
<td>(DR/CPE)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2.69)</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.853</td>
<td>0.908</td>
<td>0.905</td>
</tr>
</tbody>
</table>

* - t-statistics are reported in parentheses.

Equation (2.2) suggests that there is also a significant difference in the willingness to pay for additional salmon. Using (2.1) and evaluating at the average, a 10 percent increase in the average catch per rod-day would increase lease values by 4.65 percent. Assuming that the number of rod-days is unchanged, this represents a marginal willingness to pay of $38 per salmon. However, from (2.2), the coefficient on the (inverse) catch rate is -0.245 for the Miramichi and -0.107 for the Restigouche. Evaluated at the average values for each river, a 10 percent increase in average...
catch would bring a 6 percent increase in Miramichi lease prices and a 2 percent increase in Restigouche lease prices. Assuming that the number of rod-days does not change, the marginal willingness to pay for a salmon on the Miramichi is $46 and on the Restigouche, $17. Since the average catch rate on the Restigouche is one-third greater than that of the Miramichi, it is consistent with utility theory that the marginal willingness to pay for salmon is higher on the Miramichi.

Empirical Estimates

The earlier literature dealing with estimating willingness to pay for hedonic price functions has recognized that such estimates are valid only under a restricted set of circumstances. The essence of the problem is that the market bid function for a characteristic, in our case $s$, is the envelope of individual agent bid functions. One can use the market function as a measure of willingness to pay only if all agents have equal incomes and preferences and are completely mobile, and if there are no supply side effects. What in fact needs to be determined is the individual agent's bid function. The difficulty is that only winning bids are observed, and it is therefore necessary to develop an "actual" estimate of the willingness to pay function from the limited information available; essentially the agent's bid function for amount of $s$, holding all else including income and utility constant.

McMillan, Reid and Gillen [4] develop a technique whereby one can translate the consumption section of Rosen's analysis [8:38-41] from the market bid function into the more familiar indifference curves and budget constraints. Using the assumption of homotheticity and a common specific form for the utility function, the bid functions are delivered (not fitted) which are consistent with the estimated value function. 3

Using this framework, a compensating surplus measure of willingness to pay can be determined from the estimated price function due to the assumption of homothetic utility functions. Thus, using typically available information and an assumption common to demand theory, a constant utility or compensated demand curve can be developed. The method is illustrated in Figure 1. The relationship between $s$ (salmon catch per rod-day) and the bid price for leases with similar other characteristics, $c$, is depicted as $V(c, s)$. Economic agents are not indifferent among locations and trade off $s$ and $c$ according to the bid functions $b(c, s)$. The lease

3These are strong assumptions but have been frequently used in demand studies (see Deaton and Muellbarn [1]).

4We assume the appropriate convexity conditions to ensure an interior optimum.
and $x_s$, we can determine the slope of the indifference curve at any desired $c,s$ combination.\footnote{Since the government controls the stocks, the supply side can be safely neglected \cite{4,8}.}

Consider that the utility of an economic agent can be characterized as:

$$u = u(c,s)$$

where $\bar{c}$ is an index of all lease characteristics except salmon per rod-day, which is represented as $s$. If $u$ is considered to be some monotone transformation of the lease prices which are functions of $c$ and $s$, one can write:

$$u = g(V)$$

and

$$V = h(c,s)$$

fixing utility at some level, the indifference surface can be represented as:

$$c = b(\bar{u},s)$$

thus from (4) and (5):

$$c = c(V,s)$$

(7) is the representation of $c(V,s)$ in Figure 1. The solution for $c(V,s)$ can be determined from a given utility function. If we assume utility is Cobb-Douglas ($U = a c^\alpha s^\beta$), at a point such as $z$ (in the left half of Figure 1), the solution is represented as:

$$c(z, s_1) = \left( \frac{\beta}{\alpha} \left( \frac{1}{s_2} - \frac{1}{s_1} \right) \right)^{-\frac{1}{\gamma}}$$

where $s_1$ is the original salmon catch per rod-day and $s_2$ is the new catch level; $c_1$ represents the original level of "other" characteristics associated with a lease and $c(V,s)$ is the change in these characteristics required to leave the economic agent at the same utility level with a change in $s$.

Table 3 contains the estimates of the marginal rates or substitution for different catches/rod-day for all leases and for Miramichi and Restigouche leases. The marginal rate of substitution indicates the rate at which leaseholders are willing to substitute other lease characteristics for salmon catch per rod-day; diminishing marginal utility is evident in all cases.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
$1/\text{CPE}$ & $s^{**}$ & MRS & MRS & MRS \\
& & (overall) & (Miramichi) & (Restigouche) \\
\hline
5.00 & .2 & 384 & 196 & 447 \\
2.08 & .48 (overall mean) & 868 & 588 & 885 \\
1.66 & .6 & 1058 & 742 & 1063 \\
1.25 & .8 & 1355 & 981 & 1342 \\
1.00 & 1.0 & 1643 & 1212 & 1615 \\
\hline
\end{tabular}
\caption{MARGINAL RATES OF SUBSTITUTION (MRS)*}
\end{table}

\footnote{calculated from equation (8).}
\footnote{salmon catch per rod-day.}

The measure of MRS can be used to calculate willingness to pay for changes in the salmon caught per rod-day. Consider a 10 percent increase in the salmon catch per rod-day, holding the number of rod-days constant. The total number of salmon caught in both river systems was 1861, or 93.05 per lease. A 10 percent increase in $s$/rod-day would increase average lease values by approximately $554. The figure calculated previously to measure the marginal value of salmon/rod-day was $38. Using the methodology developed, the marginal willingness to pay is $41.41 per salmon/rod-day. A 10 percent decrease in salmon/rod-day yields a calculated value of willingness to pay of $64.96. Using the hedonic function, the elasticity of lease value with respect to salmon catch per rod-day was approximately .5 while the value from the above calculations is .7.

Conclusions

We have presented a method whereby the typically limited information from lease auctions and characteristics of leases can be used to derive willingness to pay for certain characteristics. We illustrate that simple calculations, assuming a constant marginal price from the hedonic function, will give biased estimates, although the extent of the bias is not overly large.

We focus on the characteristic of salmon catch per rod-day. The information derived as to the willingness to pay for increases in the salmon catch are useful in evaluation programs designed to augment the stock of salmon (such as increases in stocks from fish hatcheries). Willingness to pay measures in large part the direct benefits of such programs and must be compared with the costs.
The method outlined also serves as a way to calculate "new" upset prices for leases with changes in any of the lease characteristics as a result of public programs. Finally, it offers a method of evaluating public fishing which is typically characterized by high fishing density and low success rates; that is, low values of s per rod-day.

Other characteristics of leases could equally well be investigated using this framework. For example, one might wish to investigate the consequences of allowing fishing effort (increases in the allowable rods/day) on the leases to rise. The long-run effects will be capitalized into lease values. We show, from the simple hedonic function, for example, that a 10 percent increase in the allowable rods/day results in an 8.2 percent increase in lease prices on average. Thus the average lease price would increase from approximately $8,000 to $8,700 per year. If we use our methodology, the average lease price increases by $652, or approximately 8 percent. Although the difference in these figures seems insignificant, the difference in present values of the lease income streams is large when taken over all leases.

References