Valuing Multiple Programs to Improve Fish Populations

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VALUING MULTIPLE PROGRAMS TO IMPROVE FISH POPULATIONS*

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Abstract

Regulatory efforts to conserve natural resources rarely consist of a single program covering a single type of resource. Evaluating the benefits and costs of multiple programs affecting multiple resources presents regulators with a problem because the net benefits of any one program depends on the effects of the others. Washington state is currently considering a number of different programs that would each mitigate negative impacts upon its fish populations. A program-by-program attempt to estimate these net benefits independently would be expensive and cumbersome. We use the Stated Preference method to estimate benefit functions for different types of fish, which allow programs to be evaluated incrementally, conditional upon the amount of fish population improvements to date.

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I. Introduction

Regulatory efforts to protect and conserve natural resources rarely consist of a single program covering a single type of resource. Efforts to protect endangered fish species, for example, may entail changes in toxic releases into water bodies, forestry practices in riparian areas, and instream flows; and they may affect more than one species of fish.

Evaluating the benefits and costs of multiple programs affecting multiple resources presents regulators with a problem, however. In principle, the net benefits of any one program depends on the effects of the others. A program-by-program attempt to estimate these net benefits independently would be expensive and cumbersome. Alternatively, regulators could evaluate programs in a sequence, using a function that measures the willingness to pay (WTP) for the improvements in the resources affected by the programs. For such functions to be useful in evaluating more than just a few programs, the range of possible improvements would need to be rather large. This is an ideal problem for State Preference (SP) methods.

In this paper, we use the SP method to evaluate the value of changes in Washington State fish populations to residents of Washington State. The waters of Washington encompass Puget Sound and coastal saltwater bodies, as well as the Columbia river system and other freshwater bodies. These waters hold a rich and varied set of fish species. These fish populations are under increasing pressure from a variety of sources; urban development, agricultural practices, timber harvesting, pollution, and hydroelectric dams all have affected the state's fish populations, either by harming them directly or by degrading their habitat.

Because of the wide variety of fish populations and impacts upon them, the state government is considering a number of different programs that would each mitigate negative impacts upon fish populations. Riparian buffer zones, changes in the operation of hydroelectric dams, and controls over toxic discharges are just a few. Independently valuing so many different programs, which could be enacted in an almost limitless number of different sequences, would be a Herculean effort. Instead, we develop an SP survey that is designed to provide benefit functions for different types of fish. With these functions, the value of a new program can be evaluated incrementally, conditional upon the amount of fish population improvements to date.

The next section discusses the SP approach that we use in this paper. Section III discusses the application of the Stated Preference approach to the valuation of Washington state fish populations. The econometric modeling and results are discussed in Section IV. Section V provides WTP estimates for Washington State residents, and VI concludes the paper.

II. The Stated Preference and Econometric Approach

The Stated Preference (SP) method, widely used in environmental valuation, market research, and transportation research, asks respondents to express their preferences over a set of alternative goods or services. Each alternative is defined by a bundle of underlying attributes. For example, the alternatives may be different recreational trips with typical attributes being the cost of the trip, travel distance, and measures of trip quality.

The general SP method encompasses a variety of different preference elicitation methods. These include asking respondents to compare two alternatives (Eom; Horowitz; Opaluch *et al.*; Swallow *et al.*), rated-pairs (Johnson and Desvousges), choose from a set of alternatives (Adamowicz, Louviere, and Williams 1994; Adamowicz *et al.* 1997; Adamowicz *et al.* 1998), rank a set of alternatives (Rubey and Lupi), or to rate on some scale (often 1 to 7 or to 10) the set of alternatives (Mackenzie; Roe, Boyle, and Teisl). We use the latter approach, analyzing the data with the censored ranking model recently developed by Layton and Lee.

Formally, we begin with the standard Random Utility Model, and assume that an individual evaluates the utility of each in a set of alternatives:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad (1)$$

where V_{ij} is the observable component and ε_{ij} is the unobservable component of overall utility U_{ij}, and where i indexes the individual and j indexes the alternative. The SP method we use is based on eliciting from individuals preference ratings of each of a set of alternatives.

If an individual provides a set of ratings with no ties, then determining their unique ordinal ranking is trivial. The ordinal econometric analysis of SP ratings data is complicated by the presence of ties in the set of ratings provided by an individual. For instance, an individual rating four alternatives labeled *A*, *B*, *C*, and *D*, might provide ratings of 5, 3, 3, 2. The implications of the model in (1) with errors from a continuous distribution is that $B > C$ or $C > B$, but in the example above we do not know the relative ranking of *B* and *C*.[1] The idea behind the censored ranking model of Layton and Lee is that the ordinal content of a set of ratings with ties can be viewed as a censored ranking, in which some part of the ranking is unobserved or indeterminate. Layton and Lee show that any censored ranking can be described by a set of underlying unique rankings. In SP ratings data which has ties, more than one ranking can be consistent with the ordinal content of the ratings data. The probability of any censored ranking can therefore be calculated as the sum of the probability of each member of the set of underlying unique rankings that are consistent with the ordering of the observed ratings. In the example above, the set of consistent rankings is comprised of $A>B>C>D$ and $A>C>B>D$ and the probability of the observed censored ranking $Prob(A> \{B \text{ and } C\} >D)$ equals $Prob(A>B>C>D) + Prob(A>C>B>D)$.

Let z represent any ranking consistent with the ratings, with probability $P(z)$. Then after arbitrarily ordering the set of consistent rankings, the probability for person i of the set of ratings can be calculated as:

$$P_i = \sum_{z=1}^{z=Z} P(z) \quad . \tag{2}$$

To use (2), a means of calculating the probability of each unique ranking $P(z)$ must be specified. A natural candidate is the rank-ordered logit model of Beggs, Cardell, and Hausman, and Chapman and Staelin. This model results if we assume that the ε_{ij} in (1) are from the type I extreme value distribution. The probability of a ranking with p ranks from m alternatives in the rank-ordered logit model is given in (3):

$$P_{ir} = \prod_{j=1}^{p} \frac{e^{V_{ij}}}{\sum_{k=j}^{m} e^{V_{ik}}} \quad . \qquad (3)$$

Each *P(z)* in (2) is calculated using (3).

III. The Application of the SP Approach to Washington State Fish Populations

The state of Washington is currently considering a number of regulatory programs that have the potential of improving the state's fish populations. Using the SP approach, we developed a survey to elicit the value of these programs to state residents.

Survey Design[2]

The state's fish populations were divided into two geographic areas, and three generic types of fish. These were:

Eastern Washington & Columbia River Freshwater Fish (CF)

Eastern Washington & Columbia River Migratory Fish (CM)

Western Washington & Puget Sound Freshwater Fish (PF)

Western Washington & Puget Sound Migratory Fish (PM)

Western Washington & Puget Sound Saltwater Fish (PS)

The status of the fish populations was described by their population 20 years ago, and their populations today. Next, a status quo or most likely situation in the absence of any new programs had to be formulated. This status quo provided the baseline from which improvements can be valued. Because there is uncertainty about the time path of fish populations over the next 20 years, two status quo levels, a "high" and a "low", were used. Each scenario described the likely course of future fish populations in the absence of any new programs. Under the high status quo, the populations would remain stable over the next 20 years (no more declines); under the low status quo, the populations would continue to decline over the next 20 years at the same rate they declined during the previous 20 years. Table 1 illustrates these two situations. The entire survey sample was split in two, with one half receiving information on the high status quo, and the other half receiving information on the low status quo.

Respondents were then asked to rate four alternative programs. Each program had six attributes: the cost of the program, and the population levels in 20 years for the five types of fish. Table 2 shows the various levels used for each attribute. Note that the table uses percentage increases for each fish type. In the survey, the absolute numbers associated with each percentage increase were shown as well. Both the high and low status quo versions used the same design based upon percentage increases, but the absolute numbers will of course be different. The status quo description was "No New Programs," which cost $0, and provided a 0% increase in the population of each fish type (relative to the trend, stable or declining, identified in the description of the status quo).

35 different versions consisting of 4 alternative programs each were created for both the low and high status quo surveys. The different survey versions were developed from basic experimental design principals, subject to the constraint that there was no alternative that clearly dominated any other alternative in a given survey (*i.e.*, there was no alternative that provided more of each type of fish and cost less money than some

other alternative). This approach uses randomly generated cyclic or "shifted" designs along the lines of Huber and Zwerina, combined with the "no dominance" constraint.

Preference Elicitation

Each respondent was asked to rate the four alternatives relative to the status quo situation of No New Programs. This was accomplished using a rating scale that went from –5 to +5, with –5 being "Much Worse" than No New Programs, 0 being "About the Same", and +5 being "Much Better" than No New Programs. Each person's four ratings implicitly provides an ordering of the five programs (No New Programs plus four new programs). The respondent was asked to keep in mind both the effects of each program on the state's fish populations, and the additional money the new programs would cost their household each month.

Earlier in the survey the respondent was asked to indicate how their household's spending would change if their income was reduced by four different amounts per month. These amounts were the same as the costs of each of the four new programs, thus making very clear that these programs cost money and prompting the respondent to think carefully about the value of fish improvements versus the value of money spent on other things. Finally, the respondent was reminded that there was no "right" answer, but that we wanted their opinion.

Survey Administration

The Stated Preference survey titled "The Future of Washington State Fish: What is Your Opinion?" was mailed to randomly selected Washington State households during the spring of 1998. Of 2819 deliverable surveys, 1917 responses were received, for a response rate of 68%. Of these 1917 respondents, 1611 provided complete, useable responses to the fish valuation questions.[3] Of the 1611 useable responses, 801 answered the "High" status quo version, and 810 answered the "Low" status quo version. In the next section we analyze these two sets of data.

IV. Econometric Analysis

A number of important theoretical considerations dictate our approach for correctly estimating the willingness to pay (WTP) to conserve fish populations in Washington State. Given the complexity of the Censored Ranking model for Stated Preference (SP) ratings data, we investigate linear in parameters specifications for the indirect utility function. A more limited class of functions are available that will allow the computation of confidence intervals for the entire range of the WTP functions. Finally, we would like to allow for the possibility, but not impose, diminishing marginal WTP.

We will first consider the standard linear indirect utility function. This indirect utility function is used in virtually all SP studies. Because it does not allow for any curvature in preferences and implies constant marginal WTP, we also consider the less commonly used logarithmic form. This form has the advantages that it is linear in parameters and one can relatively easily compute confidence intervals for each WTP function. While this function satisfies many of the theoretical properties described above, it still lacks flexibility. For this reason we introduce a modification of the logarithmic form. This function allows for the WTP to be unrestricted between the first two levels of improvements in the experimental design (0 and 5% for each fish type), but logarithmic thereafter. This allows for different curvature than the logarithmic form, but utilizes the same number of parameters, is linear in parameters, and for our data yields a large improvement in the overall fit of the model relative to either the standard linear or logarithmic specifications.

Model Estimates

The linear specification for indirect utility is:

$$U_j = \beta_C \text{Cost}_j + \beta_{CF} \text{CF}_j + \beta_{CM} \text{CM}_j + \beta_{PF} \text{PF}_j + \beta_{PM} \text{PM}_j + \beta_{PS} \text{PS}_j \quad , \qquad (4)$$

where U_j is the utility the respondent receives from program j (we have dropped the i subscripts used in equation (1)). This formulation allows for each fish type (CF, CM, PF, PM, PS) to be in either levels (millions of fish) or as the percentage improvement from the status quo. In Table 3A we report results with each fish type entering in millions of fish. (The log likelihood, which is what is important for comparing different models, is the same when each fish type is entered as the percentage improvement from the status quo.) For both the low and high status quo models, we see that everything behaves in an economically reasonable fashion with increases in each fish type being positive, and increases in costs being negative.

The next specification we compare to the standard linear specification is the logarithmic model.

$$U_j = \beta_C \text{Cost}_j + \beta_{CF}\ln(CF_j) + \beta_{CM}\ln(CM_j) + \beta_{PF}\ln(PF_j) + \beta_{PM}\ln(PM_j) + \beta_{PS}\ln(PS_j) \quad (5)$$

Given that the log of zero is negative infinity, we estimate (5) with fish populations entering as millions of fish. The results for this specification are shown in Table 3B. We note that this specification yields an improvement in the log likelihood for both versions of the survey. A standard econometric practice when comparing two non-nested models with the same number of parameters is to choose the one with the higher likelihood value. This practice can be justified using the Likelihood Dominance Criterion of Pollak and Wales, which is an asymptotic criterion for (non-nested) model selection. On this basis we can see that the log model is superior to the linear model.

As discussed above, the logarithmic model has many advantages, namely that it is the simplest model that allows for diminishing marginal WTP. Next we specify a modification of the logarithmic model that allows for different curvature than in (5), but only requires the same six parameters as in (5). This specification is linear over the first 5% of increases, and then is logarithmic thereafter:[4]

$$U_j = \beta_C \text{Cost}_j + \beta_{CF} f(CF_j) + \beta_{CM} f(CM_j) + \beta_{PF} f(PF_j) + \beta_{PM} f(PM_j) + \beta_{PS} f(PS_j) \quad (6)$$
$$\text{Where: if } x < 5\% \text{ then } f(x) = x; \text{ if } x \geq 5\% \text{ then } f(x) = \ln(x).$$

The improvements in the five fish types are now entered in percentage increases from the status quo, and indirect utility for a 0% increase for each fish type which costs \$0 is normalized to equal zero. That is we normalize utility at the status quo to equal zero (this is different than in (5)). Given the experimental design, this specification allows the WTP function to be unrestricted from 0% to 5%. We will interpret changes in this range by using a linear interpolation for values from 0% to 5%, but other functions could be justified. We should note that this is an alternative functional form, not an "approximation" that handles the log of zero. The results for this model are reported in Table 3C. Using the likelihood dominance criterion, this specification is a great improvement over (5) or (4). On this basis we choose specification (6), the modified log specification, as the appropriate model for computing WTP. Before discussing the WTP functions, we would like to point out that the models for both survey versions have the appropriate signs and are extremely significant.

One might ask why (6) works better than (5) which looks so similar. Basically the modified log function places fewer restrictions on how the WTP for the first 5% increase is related to all of the other percentage changes. This turns out to be important because 5% is an important point in the design, being the smallest amount at which something is being "done" for each population. The survey responses (and a review of the literature) indicates that this point can be important and it is an improvement when we don't force the value for 5% to have a large impact on the shape of the rest of the WTP function.

V. WTP Results and Discussion

Given the specification in (6), we can calculate the WTP for any improvement as the cost that would equate the utility before the program with the utility after the program. Because the indirect utility function is additively separable in each fish type, we can calculate the WTP separately for a program's impact on each fish type and then add them. Remembering that indirect utility for the status quo is normalized to equal 0, the WTP to go from the status quo to a greater than 5% improvement implied by (6) is:[5]

$$\text{WTP} = \frac{\beta_{fish}\left(0 - \ln(\text{fish}\,\%)\right)}{\beta_{cost}} \tag{7}$$

Once we are past the status quo, one can calculate the WTP to go from any state 1 to state 2 as $\text{WTP}_2 - \text{WTP}_1$ where WTP_1 and WTP_2 are calculated as the WTP to go from the original status quo to state 1 and the WTP to go from the original status quo to state 2, respectively.

As the sampling distribution of the estimated WTP function is not normal, to compute confidence intervals for the entire WTP function for each fish type, we simulate the distribution of

$$\text{WTP} = \frac{\beta_{fish}}{\beta_{cost}} \tag{8}$$

which is the factor by which we multiply the change in populations. We used the method of Krinsky and Robb. Table 4 shows the confidence intervals for the negative of (8).[6] The 95% confidence intervals are shown as – or + 95%. Figure 1 shows one example of the WTP function, for Pacific/Western Washington Freshwater fish (PF) from the High Status Quo. As described elsewhere, in order to compute WTP for increases below 5% we have linearly interpolated the WTP between 0% and 5%. This leads to the kink at 5% and makes clearer how this functional form is different from a standard log function.

The fact that the model is estimated in percents may make interpretation of the results somewhat difficult, as many studies express values in $ per fish for a given population (in our case, all Washington State residents). So Table 5 considers a very large 50% increase in every type of fish, and then for an approximate 2,000,000 Washington state households computes the average WTP per fish for each fish type (not marginal WTP per fish). Table 5 indicates that for both survey versions the average per fish WTP is greatest for CM and then PM which mirrors accepted thought.

Finally, we compute WTP for two scenarios. The first is in the low status quo version returning both CM and PM back to their current levels, which requires a 300% increase for CM and a 100% increase for PM. The 300% increase for CM is out of the range of the experimental design, but extrapolating yields a WTP for a 300% increase in CM of $27.66 per month per household. For PM the 100% increase from the low version yields a value of $33.70. So the total for the program would equal $61.36 per month per household. The second scenario is that in the high status quo of doubling both CM and PM. This yields a value of $11.67 for CM and of $24.52 for PM, for a total of $36.19 per household per month.

We can compare our results to two studies that previously estimated the WTP for migratory fish. The Elwha dam removal study by Loomis discusses that the dam removal would improve salmon populations by 300,000 fish. The Olsen, Richards, and Scott study considers doubling Columbia river salmon and Steelhead populations. These two studies give us a relatively small change in Pacific Migratory fish (PM) and a large change in Columbia Migratory fish (CM) to compare with the values derived from our study. One thing that is important to point out is that what we have done here is far harder. We have estimated WTP for improvements of five different types of fish for any reason, from no change up to 150% for one of the types. The two studies we will discuss attempt to place a value for one change for one fish type. What we should take away from the comparison is that for two different types of fish and for small and large changes the WTP functions we estimate are in a similar range. This is very encouraging, especially given that it is harder to be accurate over a wide range of many things as compared to one change. Further, looking at our confidence intervals we can see that this was accomplished without a comparable increase in uncertainty.

If you start at our high status quo of 5 million fish for Pacific Migratory, the 300,000 salmon improvement in Loomis translates into a 6% improvement. This work out to $9.54 per month per household, or $114.48 per year, with a 95% confidence interval of $89.76 - $139.65. Loomis' results for Washington state residents gave a mean WTP of $73 with a 90% confidence interval of $60 to $99.[7] Of course there are differences between the studies, namely that he used a 10 year pay period and we used a 20, and so discounting becomes an issue, but the proper discount rate is what households use and not the social discount rate, since this is about discounting their direct payments. Also, while we can not tell for sure, it appears that in the Elwha study the total number of salmon, much less other fish in the state was not given, so for us to come close is heartening. Note that given the shape of the WTP function, if the proper status quo in the Elwha study was say 5.2 million (so a decrease of 200,000 salmon over the last four to five years), then we would compute the WTP as the difference between the WTP for a 4% increase (from 5 million to 5.2 million) and the WTP for a 10% increase (from 5 to

5.5 million – 5.5 is 300,000 greater than 5.2). This equals \$5.40 per month or \$64.80 per year (using linear interpolation over the 0%-5% range).

The Olsen, Richards, and Scott study considered a doubling of Columbia river salmon and steelhead from 2.5 million to five million. Our High version for CM has a status quo of 2 million, so the Olsen, Richards, and Scott status quo represents a 25% increase over ours. 5 million CM represents a 150% increase in CM for our study. So using our high status quo values for CM, we get \$12.70 - \$8.16 = \$4.54 per month per household. Using Table 2 of their study, we computed a WTP of \$4.19 per household per month. Their study broke out the values by recreational users, non-users who might use the resource, and non-users who won't use the resource, so we average across all three groups as our study considers these three types as one group. The values from the two studies come very close.

VI. Conclusion

This research discussed the design and analysis of an SP survey designed to allow the estimation of benefit functions for five different types of fish over a very wide range of population improvements. The specification testing indicated that an indirect utility function with curvature was preferred. Our results exhibit diminishing marginal value of population improvements for all five types of fish. This means that the benefits of a program designed to improve fish populations will depend critically upon its placement in a sequence of programs. Knowing that officials desire a benefit function that will allow them to value new programs over the course of a number of years, a critical feature of this study is a model that allows for diminishing marginal value.

Table 1

Fish Population Trends Used in the Survey

Fish Type	Population 20 years ago	Population Today	Population in 20 years with No New Programs (HIGH)	Population in 20 years with No New Programs (LOW)
EW/Columbia				
Freshwater Fish (CF)	192 million	120 million	120 million	75 million
Migratory Fish (CM)	8 million	2 million	2 million	0.5 million
WW/Puget Sound				
Freshwater Fish (PF)	93 million	70 million	70 million	53 million
Migratory Fish (PM)	10 million	5 million	5 million	2.5 million
Saltwater (PS)	860 million	215 million	215 million	54 million

Table 2

Attributes and Attribute Levels Used in the Survey

Attribute	Attribute Levels
Cost	$ per month for 20 years: $0, $4, $8, $12, $25, $45, $75
EW Fresh (CF)	Increases of: 0%, 5%, 15%, 33%, 60%
EW Migratory (CM)	Increases of: 0%, 5%, 10%, 33%, 80%, 150%
WW Fresh (PF)	Increases of: 0%, 5%, 15%, 33%, 50%
WW Migratory (PM)	Increases of: 0%, 5%, 15%, 33%, 60%, 100%
WW Salt (PS)	Increases of: 0%, 5%, 15%, 33%, 60%, 100%

TABLE 3A
Linear Specification
(in millions of fish)

	"High" Status Quo, Ver. 1-35			"Low" Status Quo, Ver. 36-70		
Parameter	Estimate	Std. Error	t – statistic	Estimate	Std. Error	t – statistic
COST	-0.0207	0.0011	-18.36	-0.0145	0.0010	-13.89
CF	0.0075	0.0009	8.36	0.0098	0.0014	6.76
CM	0.1616	0.0236	6.85	0.7577	0.0917	8.26
PF	0.0152	0.0019	8.06	0.0269	0.0025	10.64
PM	0.1341	0.0138	9.70	0.3230	0.0266	12.14
PS	0.0033	0.0003	10.03	0.0150	0.0013	11.79
	801 Obs. , Log like. = -2784.16			810 Obs. , Log like. = -2809.12		

TABLE 3B
Log Specification
(in millions of fish)

	"High" Status Quo, Ver. 1-35			"Low" Status Quo, Ver. 36-70		
Parameter	Estimate	Std. Error	t – statistic	Estimate	Std. Error	t – statistic
COST	-0.0218	0.0012	-18.90	-0.0156	0.0011	-14.65
CF	1.1102	0.1384	8.02	0.8926	0.1385	6.45
CM	0.5014	0.0762	6.58	0.5958	0.0738	8.08
PF	1.2685	0.1626	7.80	1.7280	0.1646	10.50
PM	0.9698	0.1000	9.70	1.1573	0.0963	12.02
PS	1.0170	0.1023	9.94	1.1661	0.0989	11.79
	801 Obs. , Log like. = -2773.24			810 Obs. , Log like. = -2792.53		

TABLE 3C
Modified Log Specification
(in Percent Increase from the Status Quo)

	"High" Status Quo, Ver. 1-35			"Low" Status Quo, Ver. 36-70		
Parameter	Estimate	Std. Error	t – statistic	Estimate	Std. Error	t – statistic
COST	-0.0266	0.0013	-21.03	-0.0207	0.0012	-17.72
CF	0.0969	0.0161	6.01	0.0768	0.0158	4.85
CM	0.0673	0.0142	4.72	0.1003	0.0136	7.37
PF	0.1051	0.0171	6.16	0.1526	0.0169	9.02
PM	0.1416	0.0158	8.98	0.1514	0.0152	9.96
PS	0.1428	0.0154	9.28	0.1655	0.0150	11.07
	801 Obs. , Log like. = -2738.79			810 Obs. , Log like. = -2742.21		

Table 4

Confidence Intervals for the Negative of the Factor in Equation (8)

	"High" Status Quo			"Low" Status Quo		
Fish Type	Mean	-95%	+95%	Mean	-95%	+95%
CF	**3.65**	2.46	4.83	**3.72**	2.25	5.20
CM	**2.53**	1.48	3.63	**4.85**	3.51	6.25
PF	**3.97**	2.70	5.23	**7.36**	5.73	9.08
PM	**5.32**	4.18	6.49	**7.32**	5.90	8.85
PS	**5.39**	4.24	6.57	**8.00**	6.53	9.54

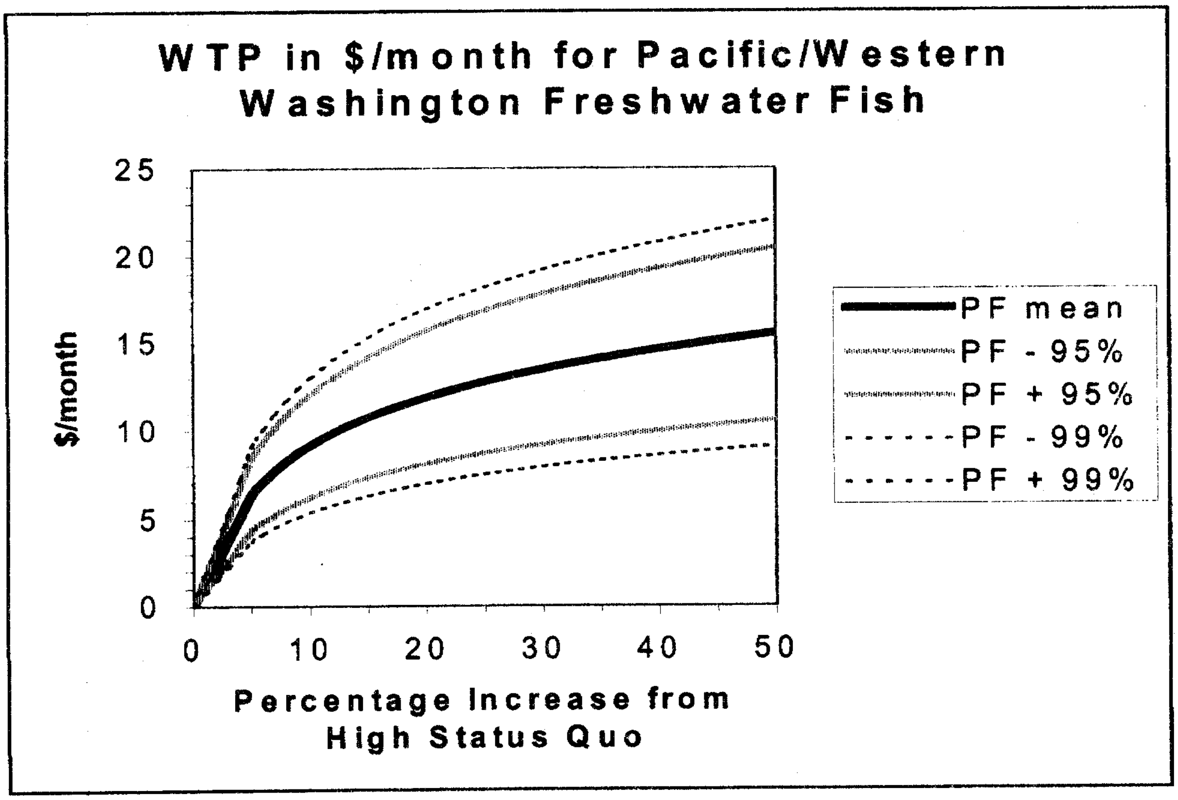
Table 5

WTP for a 50% Increase in Each Fish Type

	"High" Status Quo			"Low" Status Quo		
Fish Type	WTP for 50% Increase*	Increase in Fish	WTP per Fish**	WTP for 50% Increase*	Increase in Fish	WTP per Fish**
CF	$14.27	60 million	$5.71	$14.55	37.5 million	$9.31
CM	$9.92	1 million	$238.08	$18.97	0.25 million	$1821.12
PF	$15.52	35 million	$10.64	$28.84	26.5 million	$26.12
PM	$20.83	2.5 million	$199.97	$28.63	1.25 million	$549.70
PS	$21.07	107.5 million	$4.70	$31.28	27 million	$27.80

*WTP per month, per household.
**For illustration, this is the WTP PER YEAR per fish, for 2 million households.

Figure 1


WTP in $/month for Pacific/Western Washington Freshwater Fish
25
20
15
10
5
0
$/month
0
10
20
30
40
50
Percentage Increase from High Status Quo
PF mean
PF - 95%
PF + 95%
PF - 99%
PF + 99%

References

Adamowicz, W., P. Boxall, M. Williams, and J. Louviere. "Stated Preference Approaches for Measuring Passive Use Values: Choice Experiments and Contingent Valuation." *Amer. J. Agr. Econ.* 80(February 1998):64-75.

Adamowicz, W., J. Louviere, and M. Williams. "Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities." *Journal of Environmental Economics and Management* 26(May 1994):271-292.

Adamowicz, W., J. Swait, P. Boxall, J. Louviere, and M. Williams. "Perceptions Versus Objective Measures of Environmental Quality in Combined Revealed and Stated Preference Models of Environmental Valuation." *Journal of Environmental Economics and Management* 32(January 1997):65-84.

Beggs, S., S. Cardell, and J. Hausman. "Assessing The Potential Demand for Electric Cars." *Journal of Econometrics* 16(1981):1-19.

Chapman, R.G. and R. Staelin. "Exploiting Rank Ordered Choice Set Data Within the Stochastic Utility Model." *Journal of Marketing Research* (1982):288-301.

Eom, Y.S. "Pesticide Residue Risk and Food Safety Valuation: A Random Utility Approach." *Amer. J. Agr. Econ.* 76(November 1994):760-771.

Horowitz, J. "Preferences for Pesticide Regulation." *Amer. J. Agr. Econ.* 76(August 1994):396-406.

Huber, J. and K. Zwerina. "The Importance of Utility Balance in Efficient Choice Designs." *Journal of Marketing Research* 33(1996):307-317.

Johnson, F.R. and W.H. Desvousges. "Estimating Stated Preferences with Rated-Pair Data: Environmental, Health, and Employment Effects of Energy Programs."

Journal of Environmental Economics and Management 34(September 1997):79-99.

Krinsky, I. and A. Robb. "On Approximating the Statistical Properties of Elasticities." *The Review of Economics and Statistics* 68(1986):715-719.

Layton, D. and S.T. Lee. "From Ratings to Rankings: The Econometric Analysis of Stated Preference Ratings Data." manuscript presented at the World Congress of Environmental and Resource Economists, Venice, Italy (1998).

Loomis, J. "Measuring the Economic Benefits of Removing Dams and Restoring the Elwha River: Results of a Contingent Valuation Survey." *Water Resources Research* 32(1996):441-447.

Mackenzie, J. "A Comparison of Contingent Preference Models." *Amer. J. Agr. Econ.* 75(August 1993):593-603.

Olsen, D., J. Richards, and R. Scott. "Existence and Sport Values for Doubling the Size of Columbia River Basin Salmon and Steelhead Runs." *Rivers* 2(1991):44-56.

Opaluch, J.J, S. Swallow, T.Weaver, C. Wessells, and D. Wichelns. "Evaluating Impacts from Noxious Waste Facilities: Including Public Preferences in Current Siting Mechanisms." *Journal of Environmental Economics and Management* 24(January 1993):41-59.

Pollak, R.A. and T.J. Wales. "The Likelihood Dominance Criterion: A New Approach to Model Selection." *Journal of Econometrics* 47(1991):227-242.

Roe, B., K.J. Boyle, and M.F. Teisl. "Using Conjoint Analysis to Derive Estimates of Compensating Variation." *Journal of Environmental Economics and Management* 31(September 1996):145-159.

Rubey, L., and F. Lupi. "Predicting the Effects of Market Reform in Zimbabwe: A Stated Preference Approach." *Amer. J. Agr. Econ.* 79(February 1997):89-99.

Swallow, S.K., T. Weaver, J.J. Opaluch, and T.S. Michelman. "Heterogeneous Preferences and Aggregation in Environmental Policy Analysis: A Landfill Siting Case." *Amer. J. Agr. Econ.* 76(August 1994):431-443.

Notes

[1] The fact that the alternatives labeled *B* and *C* are tied in ratings space does not necessarily imply that they are tied in terms of utility. The model of Layton and Lee proceeds from the position that the utility of *B* and *C* may or may not be close, but the ordinal content in the example is simply that *A*> {*B* and *C*} >*D*, without knowing whether if forced to choose between *B* and *C* the individual would choose *B* over *C* or *C* over *B*.

[2] Four professionally conducted focus groups pretested the survey instrument.

[3] Actually, 1636 complete and valid responses were received, but 25 respondents provided ties to all four programs. Although these 25 are valid responses, they provide no ordinal information about these respondents preferences and therefore have no impact on the estimation and are omitted. (To represent the censored ranking for these respondents requires all possible rankings, which means that the probability sums to one for any and all parameters values, thus these 25 respondents contribute no information to the estimation.)

[4] Given the experimental design which for all five fish types includes no points between 0% and 5%, it is functionally equivalent to view this as normalizing the function at zero and leaving the function unrestricted between 0% and 5%. The linear then logarithmic interpretation is consistent with how we impute WTP over the 0% to 5% range of improvements, but other interpretations over this range are equally acceptable.

[5] For less than 5% improvements, one needs to make assumptions about the indirect utility function between 0% and 5%. We have chosen to interpret this as linear in (6), which would mean that over this range the ln(*fish*%) term would be replaced by *fish*%. As mentioned earlier, other assumptions are equally acceptable. Note that this need only

be done for the first 5%, not every 5% thereafter. After one reasonably small project the function is fully specified. (7) also makes clear that the specification in (6) is different from (5) because the WTP for (5) would be calculated as:

$$\mathrm{WTP} = \frac{\beta_{fish}\left(\ln(\text{baseline fish in millions}) - \ln(\text{fish in millions})\right)}{\beta_{cost}}$$

[6] Rounded to two decimal places. The medians were always within a penny or two of the means.

[7] This is the value for "Rest of Washington" from Loomis' Table 2. If it were provided, Loomis' 95% confidence interval would overlap with ours more.