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Welfare Effects of Fishery Policies: Native American Treaty Rights and Recreational Salmon Fishing

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Severe declines in Pacific Northwest salmon stocks, coupled with increasing recreational demands, and judicial decisions supporting Native American fishing rights create challenges for fishery agencies. This article explores the welfare effects on recreational anglers of alternative salmon allocation policies to meet Native American treaty rights. A discrete choice random utility model, coupled with a Poisson trip frequency model, is used to analyze these welfare effects. The model is fit to survey data from the Willamette River spring chinook fishery, an important recreational fishery in Oregon. Management options have dramatically different welfare effects.

Key words: random utility model, recreation, salmon, treaty rights

Introduction

Fish and wildlife resources provide services to a diverse set of users. In the Pacific Northwest, salmon have long been harvested by Native Americans and were also important to early European settlers. Salmon continue to serve the cultural and religious needs of Native Americans in the Pacific Northwest and are a major recreational resource.[1]

Severe declines in many Pacific Northwest salmon stocks, increasing recreational demands for remaining stocks, and judicial decisions concerning Native American fishing rights create challenges for fishery management agencies. Policy options chosen by decision makers in managing and allocating salmon stocks are likely to reduce the welfare of some user groups. As a result, management agencies increasingly seek information concerning the effects of alternative policies on the cultural and economic well-being of different constituencies.

This article explores the welfare effects of alternative ways of allocating salmon stocks across two important user groups in the Pacific Northwest: recreational anglers and Native Americans. The study area is the spring chinook fishery in the lower Willamette River, Oregon, one of the most important recreational salmon fisheries in the region. Given the multisite characteristics of this fishery, a discrete choice random utility model (RUM), coupled with a Poisson trip frequency model, is used to analyze the welfare changes due to different management options. Random utility models allow consideration

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[1] Salmon are an integral component of religious ceremonies and celebrations, both as a food item and as an icon, for many Native American tribes.

of substitution possibilities in response to quality changes or site closures (Coyne and Adamowicz; Bockstael, McConnell, and Strand; Morey, Rowe, and Shaw). Trip frequency models predict participation as a function of site attributes and other factors. Two hypothetical policies, motivated in part by the need to meet potential Native Americans' treaty rights to harvest Willamette River spring chinook, are evaluated. The RUM analysis provides information on the implications of these policies for the welfare of recreational anglers.

Background

An annual spring chinook salmon run bound for the Willamette River enters the Columbia River beginning in mid-January. In the Portland area, the run peaks in March and tapers off in May. The fish are highly prized by recreational anglers, as both table fare and as a sport fish. The lower Willamette River, the focus of this study, is also noteworthy because its 48-mile stretch passes through the Portland metropolitan urban area. Specifically, the study area lies through the center of the Portland metropolitan area between Oregon City and the confluence of the Willamette and Columbia Rivers at the town of St. Helens. The recreational fishery in this dense urban setting is highly congested.

The Oregon Department of Fish and Wildlife (ODFW) has established a goal of an annual minimum run size of 100,000 fish entering the Columbia bound for the Willamette River. The 1976–85 average was 63,500 (Carter and Radtke). The run, which is roughly 75% dependent upon hatchery production, achieved target goal for the first time in 1988 (Bennett). The 1986–93 average run size was 86,000 (Bennett and Foster). Angler use has also increased from a 1974–79 average of 147,000 angler days to 213,000 angler days for the 1986–93 period.

Prior to 1994, the fishery was allocated to two user groups: commercial gill-netters (in the lower Columbia) and recreational anglers (in the Willamette and tributaries). However, in 1994, the upriver Columbia spring chinook run *crashed* from a predicted 49,000 escapement over Bonneville Dam to fewer than 20,000. Native American tribes, who are allotted 50% of the Columbia escapement, were then ordered by the ODFW to cease fishing on the Columbia River before they caught their allotment of salmon for traditional religious and cultural ceremonies. As a result of the Columbia closure, some tribes asserted a claim to the Willamette River spring chinook run, which remained relatively healthy in 1994. The addition of a Native American harvest in the Willamette-bound spring chinook fishery increased competition for the stock currently allocated to recreational anglers.[2] Decisions by the ODFW and other agencies to meet the legitimate needs and treaty rights of the tribes, including reductions in recreational harvest or closure of a portion of the river, will change the attributes of various fishing sites (such as the catch rate or eliminating sites), thus hurting recreational anglers.

Data from a 1988 survey, sponsored by ODFW, provide an opportunity to investigate potential welfare effects of changes in harvest rates and site closures on the recreational fishery (Davis and Radtke). A sampling plan based on previous ODFW fishing participation and success surveys and developed by the Survey Research Center of Oregon State University divided the lower 48 miles of the Willamette River into three sampling

[2] A further complication is the 16 August 1994 listing of the summer and fall Snake River chinook as endangered. One implication of this listing is more restrictions on tribes of Columbia River chinook harvest ("Chinook Runs").

sections (the lower, middle, and upper river), with a fourth section encompassing a major tributary, the Clackamas River. These four sites (or reaches) and access points within each site, make up the choice set for lower Willamette spring chinook anglers.

Theoretical Background and Model Development

The welfare analysis requires developing two relationships. The first is a discrete choice or random utility model (RUM) concerning the choice of fishing site. The random utility model is used to estimate the welfare change caused by quality changes at each site on a per trip basis.[3] Aggregate changes in welfare across a season are estimated with a trip generation function which is a function of individual angler characteristics and the utility provided by each choice (from the RUM). The trip generation function is developed based on the results of Yen and Adamowicz and Englin et al. The development of the random utility model and trip generation functions are presented below.

Random Utility Model

In the discrete choice modeling framework, each person (indexed by i) on each choice occasion has available a set of alternative destinations, S_i. A person i visiting site j is assumed to obtain utility equal to $U_{ij} = U(Q_{ij})$, where Q_{ij} is a vector of site j's characteristics as perceived by person i (e.g., travel cost from i's home to the site and/or the quality of the recreation site). The utility from a visit to j by i has two parts: a portion which is observed by the researcher (and common to the visitors), say $V_{ij} = V_{ij}(Q_{ij})$, and a component that is not observable by the researcher, e_{ij}. Therefore,

$$(1) \qquad U_{ij} = V_{ij}\,(Q_{ij}) + e_{ij}.$$

Estimation then proceeds by specifying a functional form for the deterministic part of utility [i.e., $V(*)$] and assuming a distribution for the unobservable component across the population. One can use this specification to estimate the probability that an individual with a given observed utility level of $V(*)$ will visit site j. The choice probabilities are estimated based on a maintained hypothesis of utility maximization. Thus, on any given choice occasion, person i will visit j if the utility of a visit to j is larger than the utility of visiting any other sites in the alternative set. Therefore, for each individual i:

$$(2) \qquad \text{Prob(site} = j) = \text{Prob}(U_{ij} \geq U_{ik}, \forall\, k \in S_i, k \neq j).$$

With $U_{ij} = V_{ij}(Q_{ij}) + e_{ij}$, we have

$$(3) \qquad \text{Prob(site} = j) = \text{Prob}(V_{ij} + e_{ij} > V_{ik} + e_{ik}).$$

If the *e*s are independently and identically distributed with a type *I* extreme value variate, then we have a multinomial logit model (McFadden). If the deterministic part of the utility function is linear, then the probability that an individual chooses to visit site j will be

[3] This differs from the traditional travel cost approach which bases welfare calculations on trips over an entire season.

Table 1. Description of Variables for Random Utility Model

Variable	Description
TC1	Variable travel cost ($0.2875 time round-trip distance) plus the opportunity cost of time measured at one-third the wage rate.
TC2	Variable travel cost plus the opportunity cost of time measured at full wage rate.
FI	Fishing quality index: derived by dividing the spring chinook catch at each site for a given time period by the total number of angler days for spring chinook at that site for that time period.
CG	Congestion variable: derived by dividing the number of fishing days reported by ODFW at each site by the amount (length) of fishable water at the site.
LNN	Natural log of number of access points at each site.

$$P_{ij} = \frac{\exp(V_{ij})}{\sum_k \exp(V_{ik})}, \qquad k = 1, \ldots, J, \tag{4}$$

and $V_{ij} = \beta' Q_{ij}$, where Q_{ij} is the vector of site attributes facing each individual and β is the vector of parameters corresponding to each variable.

Specification of the Random Utility Model

Six specifications of the RUM are estimated in this article. These models contain different site attributes; that is, the variables included in the vector Q_{ij} are different. The variables are described in table 1. The multiple specifications of the RUM are intended to test the stability and robustness of the modeling approach. The six specifications are given below: three different combinations of variables are crossed with two definitions of the travel cost (*TC*) variable, differing in how the opportunity costs of travel time are specified.

Model 1: $U_{ij} = V(Q_{ij}) + e_{ij}$, where $Q_{ij} = (TC1, FI)$
Model 2: $U_{ij} = V(Q_{ij}) + e_{ij}$, where $Q_{ij} = (TC1, FI, CG)$
Model 3: $U_{ij} = V(Q_{ij}) + e_{ij}$, where $Q_{ij} = (TC1, FI, CG, LNN)$
Model 4: $U_{ij} = V(Q_{ij}) + e_{ij}$, where $Q_{ij} = (TC2, FI)$
Model 5: $U_{ij} = V(Q_{ij}) + e_{ij}$, where $Q_{ij} = (TC2, FI, CG)$
Model 6: $U_{ij} = V(Q_{ij}) + e_{ij}$, where $Q_{ij} = (TC2, FI, CG, LNN)$

There are four general site choices (reaches or sections of the river) in the choice set: lower section, middle section, and upper section of lower Willamette River, and the lower Clackamas River. Within each reach or section are multiple access points (a minimum of six). The probability of an individual *i* choosing a certain fishing site or reach of the river based on the site attributes is

$$\text{Prob(person } i, \text{ site } j) = \frac{\exp(V_{ij})}{\sum_{k=1}^{4} \exp(V_{ik})} = \frac{\exp(\beta' Q_{ij})}{\sum_{k=1}^{4} \exp(\beta' Q_{ik})}, \tag{5}$$

where

$j = 1$, if lower section of Willamette River is chosen by individual i,
$j = 2$, if middle section of Willamette River is chosen by individual i,
$j = 3$, if upper section of Willamette River is chosen by individual i, and
$j = 4$, if lower Clackamas River is chosen by individual i.

The functional form typically chosen for $V(*)$ is linear. Thus, the specification of Model 1 is

$$V_{ij} = \beta^1 FI_j + \beta^2(Y_i - TC_{ij}), \qquad i = 1, \ldots, n \qquad j \in S_i, \tag{6}$$

where Y_i is income, TC is the travel cost of visiting the site, and βs are parameters to be estimated. Income is dropped because it does not vary by site. The parameter β^2 is the marginal utility of money which plays an important role in welfare changes.

Welfare Analysis

If an individual is assumed to have the property right to the initial or prepolicy quality level of a site, then the measure of change in economic welfare caused by a change in site quality is the amount of money paid or received that would leave the individual as well off as without the change (compensating variation, CV). In the random utility framework, the value of a change in a site attribute is the change in travel cost needed to keep the individual at the same utility level as before the change. The following formula, derived by Hanemann, shows the calculation:

$$CV_{i,j} = \frac{\ln\left\{\sum_{k=1}^{J} e^{V(Q_{ki})}\right\} - \ln\left\{\sum_{k=1}^{J} e^{V(Q_{k0})}\right\}}{\beta^2} \qquad k = 1, \ldots, J \qquad i = 1, \ldots, n, \tag{7}$$

where J is the number of choices facing each individual; Q_{ki} is the vector of new site attributes facing each individual; and Q_{k0} is the vector of original site attributes facing each individual.

Similar calculations can be used to obtain the loss from deleting a site with a specified set of characteristics from the individual's choice set. The expression is

$$CV_{i,J-1} = \frac{\ln\left\{\sum_{k=1}^{J} e^{V(Q_{ki})}\right\} - \ln\left\{\sum_{k=1}^{J-1} e^{V(Q_{k0})}\right\}}{\beta^2} \qquad k = 1, \ldots, J-1, J, \tag{8}$$

where J is the number of choices for each individual. These welfare measurements are based on a single choice occasion.

Trip Frequency Models

As discussed by Morey it is difficult to interpret the per trip welfare estimates without a model that generates seasonal trips (unless each trip is independent). Yen and Adamowicz develop a trip generation model which nests the per trip RUM with a Poisson

Table 2. Description of Variables for Trip Frequency Model

Variable	Description
TP	Individual's spring chinook fishing trips.
IV1	Inclusive value of each site. This variable is calculated from the parameters of the discrete choice model with travel cost defined as *TC1*.
IV2	Inclusive value of each site. This variable is calculated from the parameters of the discrete choice model with travel cost defined as *TC2*.
AG	Age of respondent.
FE	Fishing experience, measured as the respondent's continuous years of spring chinook fishing.
IM	Scale of importance of fishing: 1—extremely important; 2—very important; 3—moderately important; 4—somewhat important; 5—not at all important.
BT	*BT* = 1 if individual owns a boat, otherwise, 0.
IN	Income category: 1—less than \$5,000; 2—\$5,000–\$9,999; 3—\$10,000–\$14,999; 4—\$15,000–\$19,999; 5—\$20,000–\$24,999; 6—\$25,000–\$34,999; 7—\$35,000–\$49,999; 8—\$50,000–\$74,999; 9—\$75,000 and over.

model of seasonal trips. According to Morey, the seasonal trip model is generated by summing a series of binomial choices during the season. As Hellerstein and Mendelsohn have also shown, the sum of these choice occasions converges to the Poisson distribution. In the trip frequency model, the number of trips taken by each individual is a function of the utility associated with a trip (the inclusive value) and the characteristics of each individual. The trip generation function is modeled here as

$$\ln(TP) = \alpha_1 + \alpha_2\, IV + \Sigma\alpha_i\, X_i + \epsilon, \qquad (9)$$

where *TP* is the number of trips taken by each individual in a season, α_1 is the intercept term, α_2 is the parameter for the inclusive value or utility (*IV*) associated with trip, and α_i are the parameters associated with the demographic variables, X_i.

Specification of Trip Frequency Model

The trip frequency model (TFM) is a function of the inclusive value (*IV*) obtained from the parameters of the discrete site choice model and a vector (*X*) of personal characteristics including: age (*AG*), fishing experience (*FE*), importance of fishing (*IM*), income (*IN*), and boat ownership (*BT*). Descriptions of the variables used in the trip frequency model are presented in table 2. The functional form of this model is as presented in (9) where variable *TP* (trips) follows a Poisson distribution with mean λ and variance λ.

The use of the inclusive value term derived from the RUM site choice model in the trip frequency model allows the two recreation choice decisions to be linked in a systematic fashion. As Loomis notes, the inclusive term "represents net utility (benefits of a site visit—directly related to site quality—minus the travel costs) from the site being available on any choice occasion and is included as a demand shift variable in the trip frequency model" (Loomis, p. 60).

Table 3. Mean Value of Site and Personal Characteristics from Oregon Department of Fish and Wildlife Survey

	TC1	*TC2*	*FI*	*CG*	*AGE*	*FE*	*BT*	Sample Size
Site 1	18.04	28.73	0.109	9.12	46.1	14.1	79	116
Site 2	11.42	20.68	0.114	7.96	49.8	16.0	76	41
Site 3	13.07	21.81	0.158	8.43	43.2	12.8	73	82
Site 4	18.81	27.25	0.114	4.06	35.15	9.9	48	27
Sample average	15.51	24.62	0.124	7.39	44.7	13.6	73	266

Note: All values except *BT* and size are means (for site or total sample). *BT* is percentage of anglers fishing from boats. Sample size reflects number of respondents at each site.

Morey, Rowe, and Shaw show the random utility model and trip frequency model can be linked together to calculate the welfare changes caused by the quality changes. In general, the change in site attributes will change welfare, which will affect the probability of site choice and possibly affect the total number of trips. Total changes in welfare can then be calculated by multiplying the change in number of trips by the change in welfare per trip. For each angler, the compensating variation (*CV*) per trip is computed by using equation (7); then the mean welfare loss per trip (over the sample) is computed as the weighted average of the individual welfare loss per trip, using the predicted trip frequency as the weight.

Data

In 1988, the ODFW funded a survey of recreational salmon anglers on the Willamette and Clackamas Rivers (Davis and Radtke). The survey targeted several groups for special analysis: anglers fishing by boat and bank, anglers fishing during the week or weekends, and the four geographic areas (lower section, middle section, and upper section of Willamette River and lower Clackamas River) established for the ODFW creel and count program.[4] Personal interviews were conducted at randomly chosen sampling sites (access points) within each of the four areas. A clustered sampling approach was used. There were five access points in site 1, four in site 2, two in site 3, and three in site 4 where interviews could be conducted. Anglers were randomly chosen and interviewed at the landing or bank fishing area. A total of 302 interviews were completed, with a refusal rate of 8%. Removing those interviews not containing complete information on day trip, income, and primary purpose of trip resulted in 266 usable observations. A summary of key economic and demographic information, by site, for the sample of anglers is in table 3.

The travel cost variable is defined as the variable cost of travel (operation cost of vehicle) plus the opportunity cost of time (see table 1). In *TC1*, for employed individuals, the opportunity cost of time is measured at one-third of the mean per hour wage rate. For students, the unemployed, retired, or homemakers, the opportunity costs of time are measured at one-third of the minimum per hour wage rate. In contrast, *TC2* uses the full

[4] The set of discrete choices in a random utility framework is an important research issue. In this study, determination of the choice set was based on previous ODFW research and data collection efforts.

opportunity costs. A value of $0.2875 is assumed as the per mile operation cost for the vehicle.

Zip code information is used to measure round-trip distance for each respondent to different sites. Measurements of round-trip distance and average speed for each respondent to different sites are used to calculate the travel time and the opportunity cost of that time.[5] The travel time was estimated by dividing the round-trip distance by the average speed to each site.

The 1988 angler survey data do not include detailed information on site attributes. This information is obtained from the 1988 Willamette River Spring Chinook Salmon Run Report, published by the ODFW (Bennett). Weekly records and estimates of spring chinook catch and angler days in different sections of the Willamette and Clackamas Rivers are used to construct fishing quality and congestion level indices for each site.

The *expected catch* is an important quality dimension of a fishing trip at these site choices. Unfortunately, an individual's expected catch rate is difficult to elicit. As a result, researchers typically rely on the realized catch per trip (the ex post measure) as a proxy of expected catch. Here, weekly records of realized trips (angler days) and catch in each section of the lower Willamette River and lower Clackamas River are used to construct the fishing quality index (*FI*).

Various approaches have been developed to model the interaction between congestion and recreation benefits (e.g., Cesario; McConnell). While a common hypothesis is that congestion will reduce an individual's willingness to pay for a recreational experience, recreationists vary in their degree of crowd tolerance. Deyak and Smith point out that congestion may have an ex ante effect on recreation. Specifically, *expected congestion* is considered by recreationists as they make their site choice decision.

Using ODFW counts (Bennett), estimates of total angler days in week $t - 1$ are used to construct the *index of congestion level* variable, CG_{jt}, for alternative sites j in week t. As has been noted for other urban West Coast salmon fisheries (e.g., Andrews and Wilen), the information flow (newspapers, TV, etc.) to anglers concerning turnout levels is particularly good relative to many sport fisheries. Finally, individual angler characteristics influence tastes and preferences and further affect site choice. Age, in this study, is a personal characteristic assumed to influence individual site choice, as do income, boat ownership, importance of fishing, and fishing experience.

Results and Discussion

Random Utility Model

Table 4 presents the results for six alternative specifications of the multinomial logit site choice model. For each model, the evidence from a separate likelihood ratio test (LRT) shows that the overall specification is statistically significant at the 0.01 level. As an additional diagnostic on overall goodness of fit, the likelihood ratio index (LRI) ranges

[5] Since travel time is obtained by dividing the round-trip distance by an assumed average speed to each section of the river, this "average speed" assumption is important. For example, section 2 ("middle river") is located in the heart of the Portland metropolitan area. Due to traffic congestion, average speed is estimated to be 22 miles per hour, the lowest average speed across the sites in the study. Assumed speeds were higher for those who travel longer distances.

Table 4. Estimation Results for Alternative Site Choice Models

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
TC1	−0.06***	−0.06***	−0.06***			
	(−8.97)	(−8.85)	(−8.77)			
TC2				−0.04***	−0.04***	−0.04***
				(−9.00)	(−8.92)	(−8.93)
FI	4.04***	2.92**	4.38***	4.08***	2.92**	4.42***
	(3.26)	(2.12)	(5.09)	(3.31)	(2.12)	(3.03)
CG		0.0004**	0.001***		0.0004**	0.001**
		(2.14)	(2.99)		(2.28)	(4.67)
LNN			1.58***			1.64***
			(6.00)			(6.19)
Loglikelihood	−310.08	−307.79	−288.35	−304.83	−302.23	−281.45
LRT	117.35***	121.93***	160.82***	127.85***	133.04***	174.60***
(χ^2)	[2 *df*]	[3 *df*]	[4 *df*]	[2 *df*]	[3 *df*]	[4 *df*]
LRI	0.16	0.17	0.22	0.17	0.18	0.24

Note: Numbers in parentheses are asymptotic *t*-statistics; one, two, or three asterisks indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

Table 5. Trip Frequency Models (TFM) for Random Utility Models 3 and 6

	TFM	
Variable	Choice Model 3	Choice Model 6
Constant	2.0825*	2.1217*
	(4.81)	(15.59)
IV1	0.1380*	
	(6.67)	
IV2		0.1410*
		(6.78)
AG	0.0063*	0.0064*
	(4.50)	(4.57)
FE	0.0099*	0.0097*
	(6.60)	(6.47)
IM	−0.4615*	−0.4563*
	(−13.61)	(−13.46)
IN	−0.0204**	−0.0297*
	(−1.93)	(−2.83)
BT	0.2392*	0.2389*
	(5.06)	(5.05)
Log-likelihood	−1,767.598	−1,765.375

Note: Numbers in parentheses are asymptotic *t*-statistics; one asterisk and two asterisks indicate significance at the 5% and 10% levels, respectively.

from 0.16 to 0.24 across alternative specifications. The logit models also pass the independence of irrelevant alternatives (IIA) test.[6]

The signs and significance of all estimated coefficients are consistent across the alternative model specifications. Models 1 through 3 use the constructed travel cost variable *TC1,* while specifications 4 through 6 use the constructed travel cost variable *TC2.* In each case, travel cost is inversely related to the probability of site choice at the 0.01 significance level. All model specifications include the fishing quality index (*FI*) variable; the estimated coefficients on *FI* are positive and statistically significant, at the 0.05 or 0.01 significance level. Four of the specifications include a congestion variable (*CG*).[7] In each case the estimated coefficient is positive and significant at the 0.05 or 0.01 level.

For this unique urban fishery, the probability of site choice is positively related to the level of congestion.[8] While this may appear anomalous to those not familiar with the Willamette spring chinook fishery, it was not unexpected. This fishery is well known for its socialization aspects, and it is likely that crowd intolerant anglers would not choose it, while crowd tolerant or crowd-seeking anglers would. Of particular note is the *hog-line* phenomenon where numerous strings of boats are tied side-by-side across key river stretches during periods of high fishing success.

A key modeling choice in estimating a recreational random utility model is the level of site aggregation. In this case, the design of the ODFW survey and available fishing quality and congestion information from secondary sources necessitated the use of the four primary sites. In Models 3 and 6, an additional variable, *LNN,* the log of the number of access sites within each of the four aggregate sites, is included. In both models, the estimated coefficient on *LNN* is positive and significant at the 0.01 level. Inclusion of the *LNN* aggregation variable does not affect the signs and significance of the other estimated coefficients (on *TC, FI,* and *CG*), and improves overall model performance (e.g., increasing the LRI results). The use of this variable has been suggested and applied by other researchers as a control on the level of site aggregation (e.g., Kaoru, Smith, and Liu).

While not the primary focus of this research, an estimate of the marginal value per fish caught can also be obtained using the multinomial logit results. The absolute value of the ratio of coefficients for *FI* and *TC* provide a rough indicator of the marginal value of a fish. Using the results from Model 3, the ratio 4.38/0.06 provides an estimate of $73. Catch rates (*FI*) in this fishery are relatively low (0.12 fish per angler day); the majority of anglers catch 0 or 1 fish per trip (with a 2 fish per day bag limit). Thus, the

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[6] A property of the logit site choice model, whereby $Prob_j/Prob_k$ is independent of the remaining choice probabilities, is termed the independence of irrelevant alternatives (IIA). This is a convenient property for estimation but not always an appropriate restriction on consumer behavior. When some of the choices are perfect substitutes, the IIA property will cause a serious bias in estimating the probability of site choice. Hausman and McFadden provide a test statistic for determining whether the IIA assumption holds. This test was applied to various site choice models. All values of test statistic are smaller than the critical values at the 0.05 significance level, suggesting that the assumptions of the logit model are appropriate for this data set.

[7] Although not presented here, a variety of alternative specifications were also conducted (e.g., including a squared term for the fishing quality index, *FI*), with no gain in estimation efficiency. All specifications were tested with and without the inclusion of the congestion variable, *CG,* with no evidence of any effects on the signs or general significance of the other variables.

[8] This result using revealed preferences is consistent with a contingent valuation study by Berrens, Bergland, and Adams, who found no evidence of congestion effects for small increases in congestion for the same fishery. Specifically, hypothetical increases of 5 and 10% in the level of congestion had no effect on estimated willingness to pay when combined with alternative increases in run size.

initial fish caught is highly valued. This calculation assumes a constant value per fish, which instead is likely to be declining with increased fish.

Trip Frequency Model

All estimated coefficients for the trip participation model are significant at the 5% level (except *IN* for Model 6) and have the expected signs. The negative sign on the estimated coefficient of *IN* indicates that people with higher income will visit less, not an uncommon result for sport fishing and hunting demand models (e.g., Loomis). In some sense, this result seems reasonable if we use *opportunity cost* to explain why higher income people visit less because their opportunity costs of visiting are higher. The significance of the estimated coefficient for inclusive values (*IV1* and *IV2*) indicate that the change of the quality of the sites will not only change the individual's utility level but also will affect the individual's visits to the site. Therefore, the mean welfare loss per trip (compensating variation) over the sample should be computed as the weighted average value of the individual welfare loss per trip, using the predicted trip frequency as the weight.

Estimation of Welfare Change Caused by the Change of Site Attributes

Two policies to meet potential Native Americans' treaty rights are evaluated here. They are (*a*) granting tribes the right to catch 5,000 spring chinook at the mouth of the Willamette River from 31 March to mid-June and (*b*) granting the *upper* river reach (site choice 3) exclusively to the tribes. The first policy will reduce the number of spring chinook in the Willamette River and reduce the fishing quality (success rate) for recreational anglers. According to the 1988 Willamette River spring chinook report, the percentage of spring chinook caught of the total run entering the Willamette is approximately 26%. Therefore, for this hypothetical policy, we assumed 5,000 spring chinook caught on the lower Willamette River by the tribes implies that 1,300 (5,000 $\times$ 0.26) spring chinook salmon will not be taken by recreational anglers on the lower Willamette and Clackamas Rivers. The reduction in fishing quality leads to benefit losses to the recreational anglers because of the maintained hypothesis that fishing quality is positively related to individual utility. The second policy is an extreme policy, which goes beyond the agreement reached between Oregon Department of Fish and Wildlife and the tribes during the 1994 season. (The 1994 agreement granted the tribes exclusive rights to only one portion of the *upper reach.*) However, there is precedence for such exclusions: recent judicial decisions concerning treaty rights have barred nontribal members from access to selected fishing sites on the Columbia River.

Estimated Welfare Losses from a Reduction in Fishing Quality

The estimated per trip losses caused by the reduction in fishing quality for a representative angler are reported in table 6. The estimated losses from the two models are fairly similar. The model using *TC2* as the explanatory variable, as expected, yields larger estimated welfare effects.

With different travel cost definitions, the policy to allocate 5,000 spring chinook to the tribes causes individual recreational angler welfare losses of \$0.4657 and \$0.7534 per trip for models with *TC1* and *TC2,* respectively. These values are small in terms of

Table 6. Estimated Welfare Loss: Changes in Fishing Quality vs. Closure of Site 3

	Welfare Loss		
Policy	Per Person per Trip	Aggregate Across Sample	Aggregate Across Population
	.... (in dollars)	....	
Change in Quality			
RUM 3 (with *TC1*)	0.4657	1,393	103,598
RUM 6 (with *TC2*)	0.7534	2,254	167,599
Closure of Site 3			
RUM 3 (with *TC1*)	3.13	8,569	697,496
RUM 6 (with *TC2*)	8.80	21,031	1,957,658

reported expenditure data. The welfare loss associated with this fishing quality change across the sample are $1,393 and $2,254, respectively.

Decision makers usually are more concerned about aggregate welfare changes. The aggregate welfare loss arising from this policy is estimated by multiplying the representative angler's loss by the total trips predicted. The total trips (angler days) to Willamette recreational fishing in 1988 are 222,457. Therefore, the aggregate welfare losses associated with this policy are $103,598 and $167,599, respectively, for Model 3 and Model 6.

Estimated Welfare Losses for Closure of Site 3

The estimated per trip welfare losses resulting from closure of site 3 to a representative angler are also reported in table 6. With different travel cost definitions, a policy which grants site 3 exclusively to Native Americans causes individual welfare losses of $3.1354 and $8.8002 per trip for Model 3 and Model 6, respectively. These values are substantially higher than for reductions in fishing quality across all sites.

The aggregate welfare loss caused by this policy across the sample is obtained by multiplying the representative angler's loss by the total trips predicted from the trip frequency function. The aggregate welfare losses across the sample are $8,569 and $21,031, respectively, for Model 3 and Model 6. Aggregate welfare loss is obtained by multiplying the mean welfare loss per trip by the total angler days predicted for the 1988 season. The estimated aggregate welfare losses to recreational anglers are $697,496 and $1,957,658, respectively.

Conclusions

Our results show that a policy allocating tribes 5,000 fish at the mouth of the Willamette River causes a welfare loss for the representative angler of $0.47 per trip (using the travel cost definition *TC1*). The corresponding estimate of aggregate welfare loss is approximately $100,000. In contrast, the welfare loss caused by the second policy, closure of site 3, is $3.13 per trip (using travel cost definition *TC1*), with a corresponding estimate of aggregate welfare loss of approximately $700,000. For recreational anglers, the closure of a fishing site will have substantially larger welfare losses. If these two policies achieve the same objective in terms of meeting Native American treaty rights, then the first policy is a clearly preferred alternative. Allocating a substantial number of fish to the tribal fishery does not appear to impose large welfare losses to the recreational fishery, as long as all fishing sites remain accessible to anglers.

Meeting Native American treaty rights in the face of declining stocks will be an ongoing issue in the Columbia River system and elsewhere in the West. As shown here, management actions to accommodate these claims can have substantially different effects on recreational angling. While findings are limited by the nature of the existing data set, the results demonstrate the potential and feasibility of discrete choice random utility modeling as a tool in analyzing recreational choice problems in the context of changing management policies.

This research could be improved by more detailed trip information, improved understanding of the opportunity costs of recreational travel time and recreational participation, and more information about the physical attributes of the sites, such as the water clarity, number of ramps, and other amenities. Future recreational surveys by state and regional planning agencies should include questions keyed specifically to the application of random utility modeling to enhance their use in addressing future recreational management problems.

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